THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

THE INSTITUTION OF

PRODUCTION ENGINEERS JOURNAL

10 CHESTERFIELD STREET . LONDON . W1 Telephone : GROsvenor 5254/9

Vol. 34, No. 4 *Price 10/-* *April 1955*

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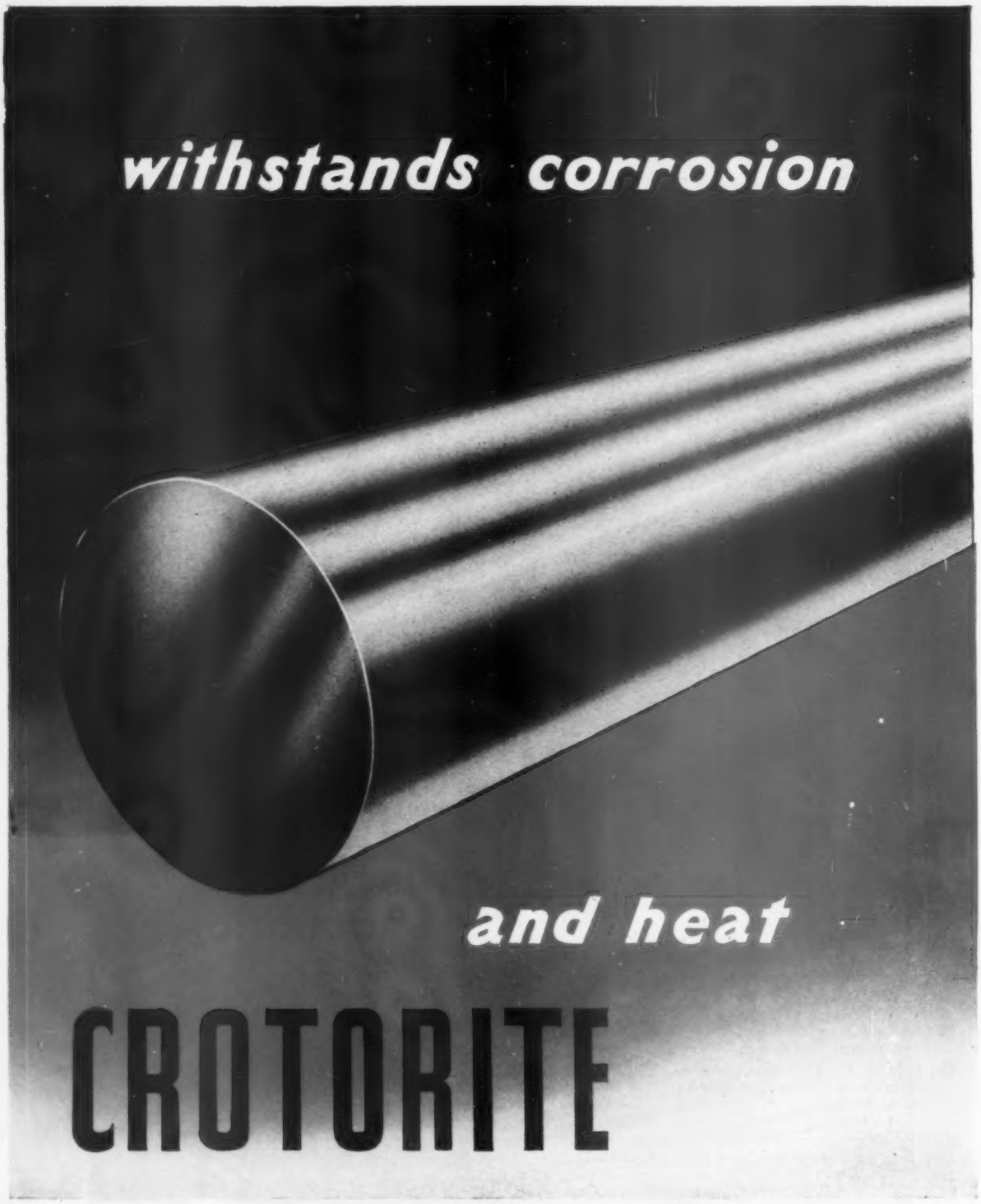

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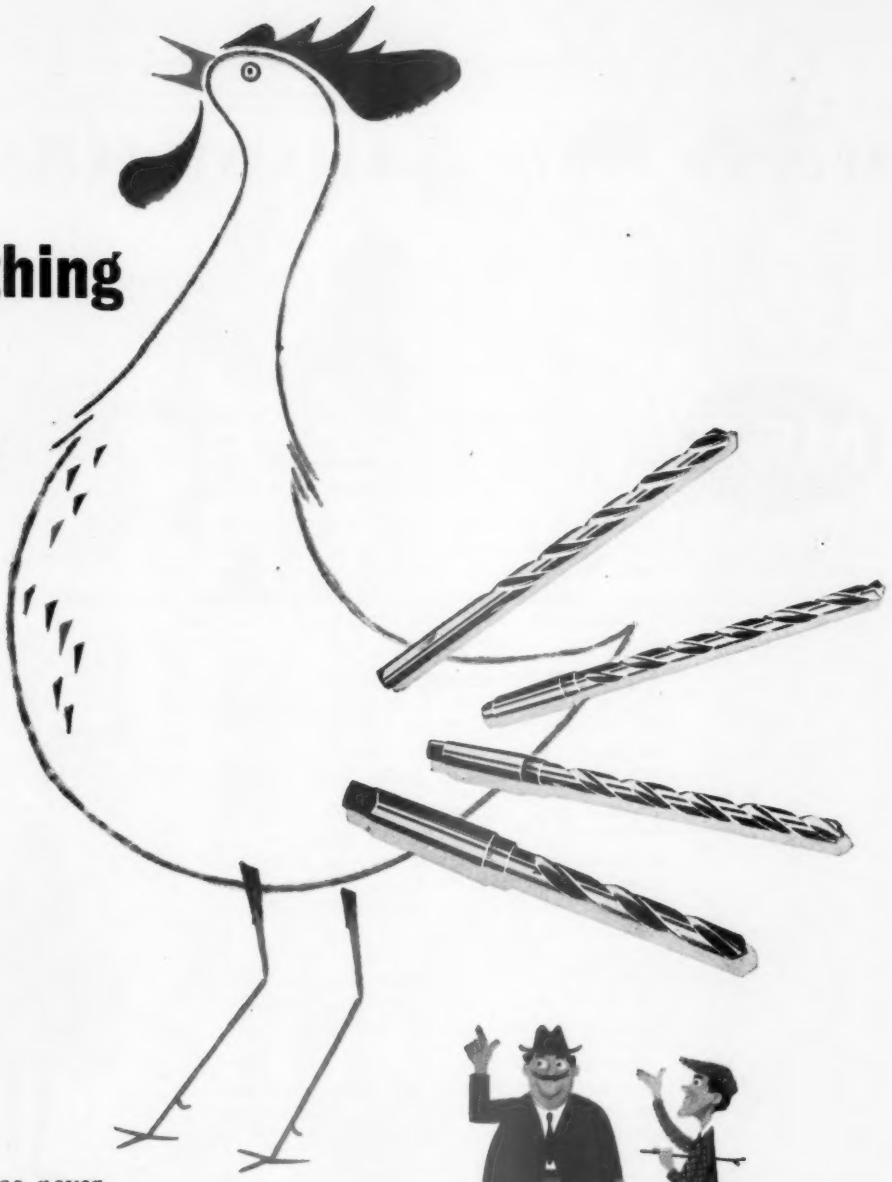

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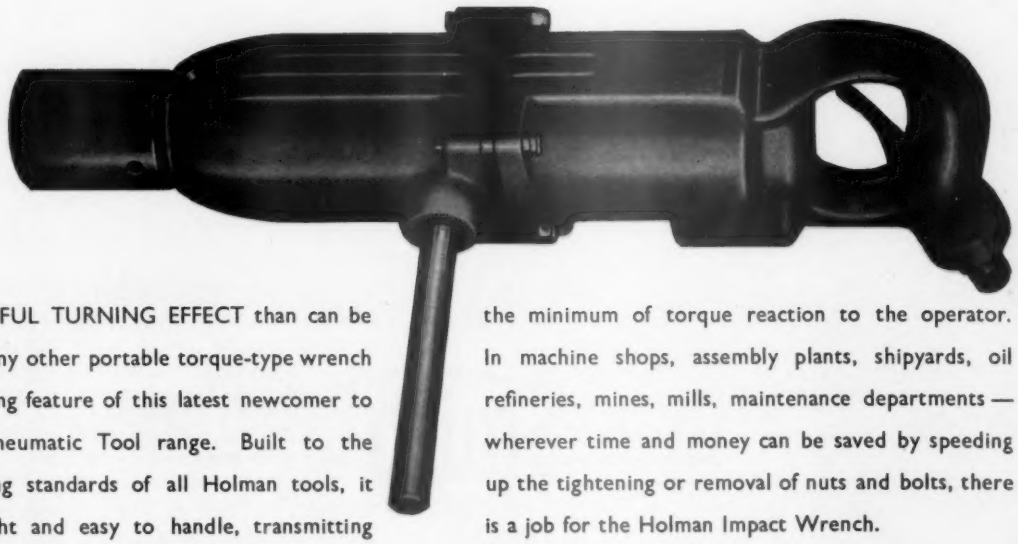

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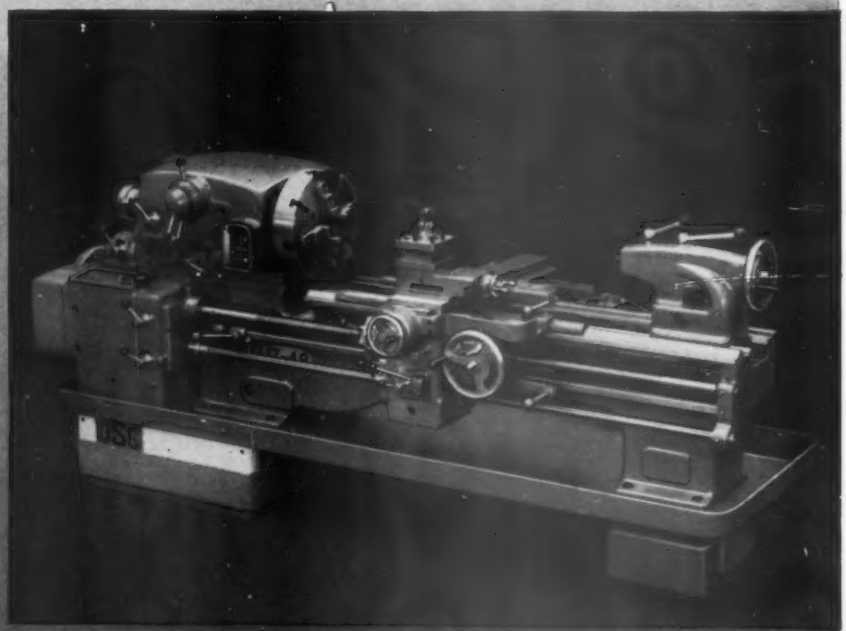

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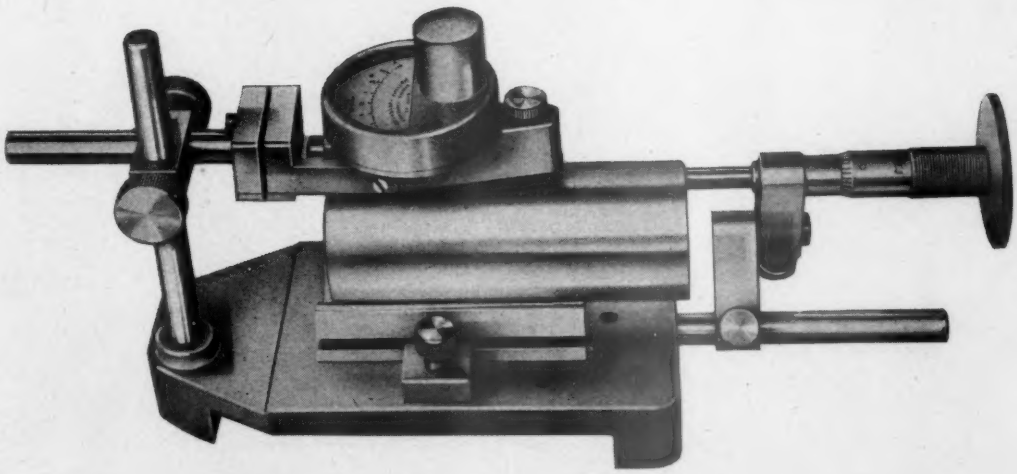

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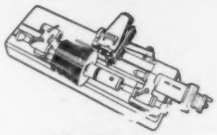

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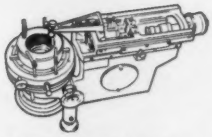

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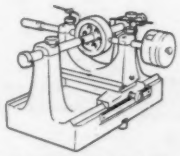

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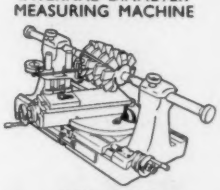

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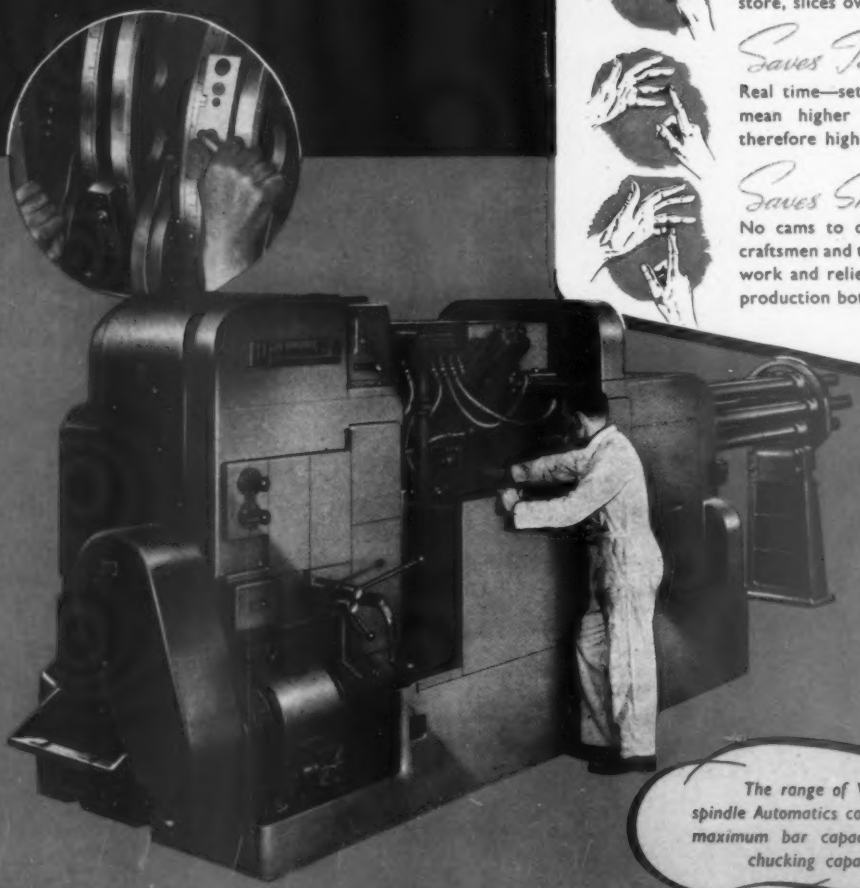

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The Institution of Production Engineers Journal
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Education and Research for Production

by C. L. OLD, B.Sc.(Eng.), A.C.G.I., M.Sc.(Tech.), M.Inst.C.E., M.I.Mech.E., M.I.Prod.E.
Principal, Wolverhampton & Staffordshire Technical College; Chairman, Institution's Education Committee.

IN contributing an article to this series on "Education and Research for Production", I am bound to think in terms of the technical college's contribution. I do not accept the assumption, held in many quarters, that the Universities, and only the Universities, can produce the best men to fill the higher and highest posts in industry, whether they be of a purely technical nature or those which involve the handling of men and processes. This assumption involves a definition of "best men" and it is probably here that thinking is not always as clear as it might be, although, before going on to this in greater detail, the following figures, taken from a Paper read by Dr. P. F. R. Venables at the Technical Colleges and Industry Conference held at Ashorne Hill in 1954 (F.B.I.), indicate the state of affairs judged by purely academic—that is, examination-passing—ability :-

"Relative proportion of students in Comparable Courses in Science and Technology in Universities and Technical Colleges (England and Wales 1952).

	University	Technical Colleges	
	Full-time Students	Full-time	Part-time-Day
Science	14,840	2,574	4,668
Technology	8,102	9,558	23,234
Total	22,942	12,132	27,902
Percentage of total in attendance	36%	30.8% (A)	9.2% (A)

NOTE (A) Percentage taken of respective totals (which do not include Art) namely 39,317 full-time and 302,183 part-time-day. This analysis does not include the large number of students taking courses for degrees and final professional qualifications in evening courses in technical colleges.

It is greatly to be regretted that no central record is kept of final professional qualifications gained by technical college students, and only the narrowest indication can therefore be given of the quality of their advanced courses, e.g. the following awards gained in 1952 :-

Number of London University Degrees (Internal)	591
Number of London University Degrees (External)	1,102
	1,693

Other University Degrees	338
Associateship of the Royal Institute of Chemistry	179
Higher National Diplomas	250
Higher National Certificates	6,311

Number of technical colleges whose students in 1953 gained London University Degrees (Internal and External)	74
Number which gained twenty-five or more degrees	14
Number with Higher National Diploma and equivalent College Associateship courses	16
Number with Higher National Certificate courses (part-time-day)	141
Number with four or more H.N.C. courses with total of not less than 200 part-time-day students	12

A survey of the period 1945-49 showed that in thirty-one of the larger technical colleges 196 original research papers in technology were published by students or staff, and 218 higher degrees were obtained."

It is worth considering, first of all, where the men come from who pass into industry or into higher education at 15 to 18 years of age. The 1944 Act set up three streams of secondary education to be end-on to primary education at the age of eleven plus. The sorting was to be according to ability and aptitude. In fact, the sorting, and hence the current meaning of ability, is purely on an intellectual basis. It tests the child's mental ability and the academic type subjects in which the Grammar Schools so well specialise. No real attempt is made to measure aptitude because nobody knows how it can be measured, especially at the early age of eleven. No account is taken of the child's temperament, of his degree of perseverance, how he gets on with his fellows and, what is perhaps more important than most people realise, the kind of home from which he comes. Quite obviously, these things cannot be taken into account, particularly the last. What kind of sequel might follow the exclusion of a child from a Grammar School because somebody on the selection board disapproved of his home ? And yet these things are very important and play a vital role in the subsequent development of the man. All that is necessary to the present purpose is to realise that these things are not taken into account when a child is selected at eleven years of age, at the beginning of his climb of the educational ladder which can lead directly to the University. The population of the Secondary Modern School is what is left over after the Grammar School, and perhaps the Secondary Technical School—although this is at the moment generally only a second-best—has taken those of first-class ratings and with a verbal ability which, in competition with others, has placed them high up on the list.

There is still an immense fund of ability left outside the Grammar Schools, providing that the word 'ability' is allowed to include other virtues than that of passing verbal type examinations. In addition, there is quite a large group of

Grammar School entrants who do not develop their greatest potential in the atmosphere of the school. In spite of having passed the hurdles at the age of eleven, there are many who gain nothing by remaining in the somewhat cloistered and academic atmosphere of a Grammar School beyond the age of, say, sixteen. Still further, there is a proportion of those who, while benefiting from participating in VIth form work, are unlikely to develop to the best advantage in a University atmosphere. Their full and final development can only come by an earlier contact with and applications of their professional knowledge although, at full development and maturity, they will be indistinguishable from their colleagues who tread the route through the Universities. It must be remembered that the function of the Universities is to develop the powers of abstract thought in its alumni away from the hurly-burly of the conditions under which these processes will eventually operate. Only a limited number of people are amenable to this treatment and it is possible that the Universities have already dipped lower into the barrel than they should have done if their own high academic standards are to be maintained.

It would appear, then, that much ability may be found in three groups of school leavers not proceeding to the Universities, each at a different level of achievement when it passes from school into industry and further education. These are the Modern School leavers of fifteen and Grammar School leavers of sixteen and eighteen years respectively. A limited number of each of these groups is capable of receiving education and training to the highest level and it is the function of the Technical Colleges to provide this among other services.

The final product can be the same from all groups but each must enter the system at his own appropriate level. The full course is naturally that available for the fifteen-year-old and, including a preliminary year, consists, to begin with, of four years of part-time study running concurrently with industrial apprenticeship for the Ordinary National Certificate. The same standard will be achieved by the second group after two years of study, providing certain essential subjects are obtained in the G.C.E. Ordinary level examination. There is, then, a rough parity between these two groups and the third which has remained at School for VIth form work, and all may now be entered on the final stage of training which consists of three years of a full-time "sandwich" course with six months alternating in the college and in industry. The first six months of study will inevitably be one of levelling up in various subjects for the different groups but, thereafter, they will proceed as a homogeneous group and, as in all such cases, the students will teach each other a great deal, thus reducing the differences even further.

There are related problems such as the award to be made to such students and questions of maintenance, as well as other matters. The award is not important from the point of view of this article—what matters is the kind of man produced. As for maintenance grants, at least one authority in the West Midlands has recently put awards to full-time students of a technical college on the same basis as awards to University students.

Naturally, only colleges with adequately qualified staff and broadly based courses and with good student facilities can be expected to undertake this kind of work, because it is equivalent to the best that can be produced by any other kind of institution.

What has been outlined above is an alternative to the University route and one capable of producing many thousands of well trained men every year, who, because of their intimate knowledge of industry from quite early years, together with a theoretical training as high in academic standard as a first degree, will be of immense value in industry.

Much could be written about National Certificate courses but these are already well known and, indeed, in common with all the professional engineering bodies, it is from these courses that a very large proportion of the Institution corporate membership has been drawn.

Third Conference on

"PROBLEMS OF AIRCRAFT PRODUCTION"

Southampton, 14th/15th January, 1955

Theme: "Integral construction contrasted with traditional methods"

The third Conference on "Problems of Aircraft Production", organised by the Southern Section of the Institution, took place on 14th/15th January, 1955, at the University of Southampton, by kind permission of the Vice-Chancellor. The full programme is given below.

The first two Sessions of the Conference were reported in the March issue of the Journal. Sessions III and IV are reported in this issue. Copies of the complete Proceedings, separately bound, will shortly be obtainable from Head Office, price 10/- per copy, post free.

SESSION I

"AIRCRAFT DESIGN PROBLEMS AND TRENDS"

Speaker: A. E. WOODWARD-NUTT, M.A., F.R.Ae.S., Principal Director of Research and Development (Aircraft), Ministry of Supply.

Chairman: Air Marshal SIR HUGH WALMSLEY, K.C.B., C.B.E., M.C., D.F.C., Managing Director, Air Service Training, Ltd.

Luncheon

Speakers: Alderman R. E. EDMUNDS, Mayor of Southampton.

Delegates to the Conference will be very sorry to learn of the sudden death of Alderman Edmunds, on the 2nd February last.

SIR EDWARD BOYLE, Bt. M.P., Parliamentary Secretary, Ministry of Supply.

Chairman: F. T. WEST, M.B.E., M.I.Prod.E., A.I.Struct.E., M.R.San.I., Chairman, Southampton Section, and Principal, Southampton Technical College.

SESSION II

(i) "PROBLEMS OF FORGING"

Speaker: G. W. RICHARDS, Director, High Duty Alloys, Ltd

(ii) "MACHINING AND FORMING PROBLEMS OF INTEGRAL CONSTRUCTION"

Speakers: E. D. KEEN, B.Sc., F.R.Ae.S., Assistant Chief Designer, Sir W. G. Armstrong Whitworth Aircraft, Ltd.

A. MENZIES, Process Development Manager, Sir W. G. Armstrong Whitworth Aircraft, Ltd.

Chairman: R. S. BROWN, M.I.Prod.E., General Manager (Aircraft), Aircraft Division, Bristol Aeroplane Company, Ltd.

SESSION III

"HIGH SPEED MACHINE TOOLS FOR AIRCRAFT PRODUCTION"

Speaker: S. RADCLIFFE, B.Sc.(Tech.), A.M.I.Mech.E., M.I.Prod.E., Technical Director, Wadkin, Ltd. (representing Machine Tool Trades Association).

Chairman: F. C. COOKE, M.I.Prod.E., General Production Manager, Field Aircraft Services, Ltd.

SESSION IV

"WHERE DO WE GO FROM HERE?"

Speaker: W. E. W. PETTER, C.B.E., B.A., F.R.Ae.S., Managing Director and Chief Engineer, Folland Aircraft, Ltd.

Chairman: F. T. WEST, M.B.E., M.I.Prod.E., A.I.Struct.E., M.R.San.I.

HIGH SPEED MACHINE TOOLS FOR AIRCRAFT PRODUCTION

by S. RADCLIFFE, B.Sc.(Tech.), A.M.I.Mech.E., M.I.Prod.E.

Mr. Radcliffe commenced his apprenticeship in 1925 with Messrs. T. Robinson & Son, Limited, Rochdale, makers of woodworking machinery. In 1928, he was awarded an Armaments Scholarship in the University of Manchester, graduating in 1931 in mechanical engineering. After additional field experience, he returned to Robinson's as a machine designer.

In 1934 he joined the staff of Wadkin, Limited, as assistant to the Works Director, and in 1938 was commissioned by the Directors to study the application of woodworking machinery to the needs of the aircraft industry, which led to the design of many types of machines during the War, for aircraft production.

Mr. Radcliffe was appointed a Director of Wadkin, Limited, in 1942, and Technical Director in charge of both wood and light alloy machinery design in 1946, a position he still holds. He joined the Institution of Production Engineers in 1934, and has just completed his term of office as Chairman of the Leicester Section.

Mr. Radcliffe

WHEN Mr. Woodley addressed the Aircraft Production Conference last year, he posed a number of problems facing the aircraft production engineer at that time and I suppose that many of those problems remain unsolved. Mr. Woodley said, amongst many other things : " The challenge which we now have to face is that of cheaper machining methods. It should be possible to adapt the ease, cheapness and versatility of the router technique to the problems of skin milling and many other components."

I am here today to report a small amount of progress in ideas which can help to reduce the cost of machining light alloys. I am the first to recognise that the contents of this Paper are only a first step on the road to supplying the aircraft production engineer with his requirements, but at least a start has been made on some elementary machines which I hope, in addition to fulfilling an urgent present need, will prove to be stepping stones to machines of greater complication which will more nearly fill the industry's needs.

The difficulties of the machine tool builders are, I suppose, well known to the aircraft industry outside the general run of standard machine tools. The high cost of development and risk of no repeat orders are familiar items to the aircraft industry, and are as well known to you as to the machine tool builders. Add to this the fact that aircraft requirements often call for machines of larger capacity than is usual, so that an adaptation of an existing design may be heavy and expensive for the duty for which the machine is required.

The approach from the wood cutting field is, I suppose, well known, and after 15 years experience it is true to say that no standard woodworking machine is suitable for full production on aluminium alloys, and the design of most successful machines for cutting alloy are a half-way house between a woodworking machine and a machine tool.

In the past year, a lot of progress has been made on routing techniques, in types of machines becoming available, improved cutters and increased horsepower. I also propose to give details of a new spar mill in process of design which I hope will meet the needs of the British aircraft industry, and a new large milling machine which may have some application. The production sawing of alloy is also receiving attention, and I am describing a special machine which will be made to deal with the large billets necessary for the development requirements of the airframe industry. Finally, I wish to give some details of cutting tests on expanded honeycomb alloy and illustrate a possible design for a bandsawing machine for handling it.

Wherever possible on machine tools for airframes of the types we are discussing today, the thought of " an extra 4′ 0″ or more " should always be in the

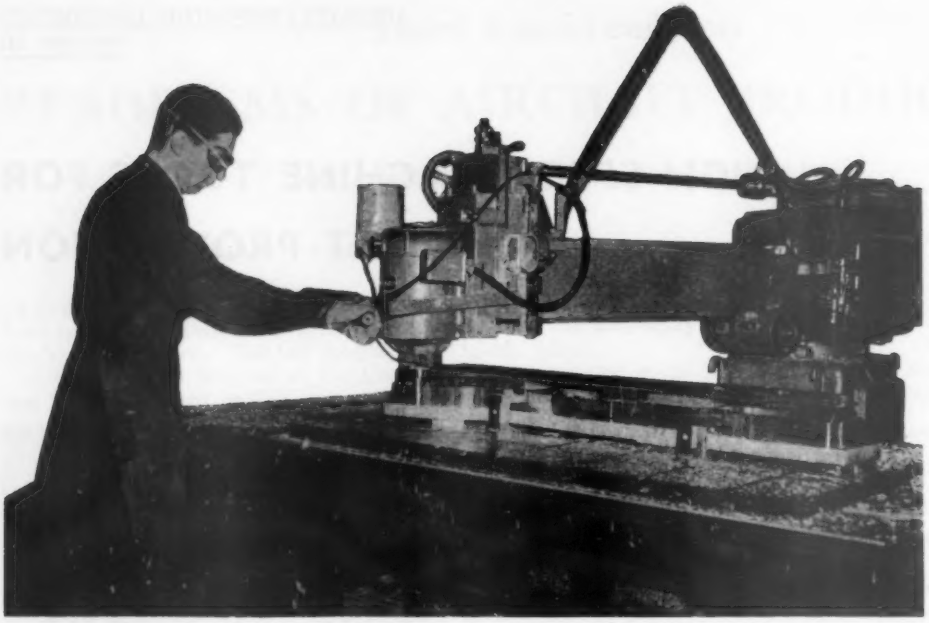


Fig. 1.

machine tool designer's mind. All beds of travelling head milling and drilling machines should be made to gauge, flanged, and ended up and drilled so that additional bed lengths and tables can be added as a matter of routine, to meet the expanding needs of the airframe designer. Wherever the design permits, openside machines can be helpful and if a removable steady is provided the best of both worlds reasonably obtained. Fortunately the cutting of alloy at router speeds (12,000 or over) does not set up big stresses and the designer has a number of choices of construction that are not suitable for tools to be used for cutting iron or steel. On the other hand, milling and sawing of alloy, using large cutters and saws at high speeds and feeds, require large horsepowers and very heavy and rigid elements, to sustain the carbide tipped cutters, and remove the material being cut, without vibration.

Routing

The technique of routing aluminium alloys has been well established in this country since 1936, using a fixed head router fitted with 2 h.p. head, running at 24,000 r.p.m.

The radial router using the same 2 h.p. unit has been in use since 1939 for general work and has been adapted to do many special operations. This machine covered material 4′ 0″ wide and any length by using a rolling table generally 8′ 0″ long, occasionally power operated up to 24′ 0″ long. For longer lengths it was economic to fit the router on a travelling carriage on a bed which also supported a fixed work table.

All these machines were limited by the power of the head and stacks of sheets up to $\frac{1}{4}$″ thick, and light profiling up to $\frac{5}{8}$″ deep by about $\frac{1}{16}$″ cut, were the limit of the power available and the general construction of the machine.

In 1945 a 5 h.p. head was introduced, giving 5 h.p. at 18,000 r.p.m. and $3\frac{1}{2}$ h.p. at 12,000 r.p.m. and this head has been used in the aircraft industry for special duties and on a heavy fixed head router where the 2 h.p. unit was insufficient.

About a year ago, a heavier radial arm router fitted with the 5 h.p. head was introduced to meet the need of the industry for a machine to profile alloy plates up to about $\frac{7}{8}$″ thick from the solid, i.e. without rough band sawing to shape, and this machine is illustrated in Fig. 1. Whilst the machine was quite suitable for this duty, it became apparent that the machine had a much wider application for profiling castings (see *Aircraft Production*, August, 1954), for roughing out large limbs up to 6′ 0″ long x 2′ 0″ wide x 4″ deep, or 4′ 6″x 2′ 6″, if prepared $\frac{3}{8}$″ oversize all round on a bandsaw (6″ deep if double-sided in character), and also possibilities in helping to rough out medium sized skin milled plates and forgings. It was also established that the machine was suitable for face milling the joint face of crank cases for diesel engines to an accuracy of about .004″, over an area of about 2′ 6″ x 18″. The air cylinder illustrated on this machine was an experiment which was used to help to hold the guide bush up to the template. It was only fitted on the one movement, being abandoned after a short period, as the operator found that he could work more quickly by normal hand operated methods. The air supply in both directions on the cylinder was controlled by a twist grip on the operating handle. Fig. 2 shows the cutter $1\frac{1}{2}$″ diameter on 3″ deep profiling and the guide bush surrounding the cutter can be seen engaging the template. When this cut is completed the packings under the template will be removed, so that the head can be lowered in stages of $\frac{1}{4}$″, until the full depth of $4\frac{1}{2}$″ is profiled.

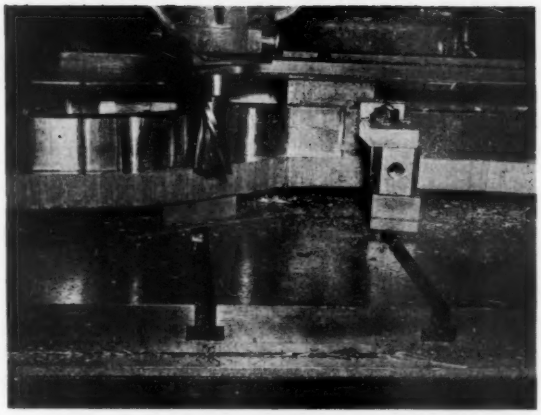


Fig. 2.

Experience with the machine was quite satisfactory, but it was obvious that if the template could be positioned above the router head, instead of being bolted directly on the work piece, the following advantages would be obtained :—

(1) The risk of cutter damage to the template would be eliminated.

(2) The choice of guide bush rollers and cutter diameters would not be restricted (when the template is on the work, the guide bush is located around the cutter and the cutter shank may have to be of small diameter and therefore weak, in order to accommodate a bush the same diameter as the cutter (see Fig. 7 and 7A)).

(3) The depth of the template and necessary height clearances are eliminated, so that it is possible to get the cutter nearer to the bottom bearing and in practice we found that we could get deeper cuts into pockets. (See Fig. 7A).

(4) It is not necessary to disturb the template once set up on repetition work, whereas with the old method, it was necessary to set up the template on each component, giving a certain amount of wear and tear apart from the time factor.

(5) For deep profiling, say 4″, it is necessary to pack the template up about 1½″ clear of the work piece, and sink in by progressive cuts of $\frac{1}{16}$″ to ½″ depth, depending upon the amount of metal to be removed ($\frac{1}{16}$″ in solid pockets, ½″ when removing $\frac{3}{8}$″ excess on the profile left by a bandsaw machine) and, after cutting 1½″ deep, remove the packing and fit the template directly on the work piece.

(6) On external profiling or pocketing operations, the pin or roller could be engaged with the template before the cutter was lowered into the work, whereas if the bush is around the cutter, it may be necessary to lower the cutter to the work and do some sinking before the bush engages the guide plate.

The prototype of this machine with overhead template is shown in Fig. 3. It has only been in use about 3 months at the Works of Messrs. Vickers-Armstrongs Ltd., South Marston, but it has already proved that the advantages claimed above are practical.

The columns and superstructure supporting the overhead template are very substantial, the columns being tied to the table and the latter to the main

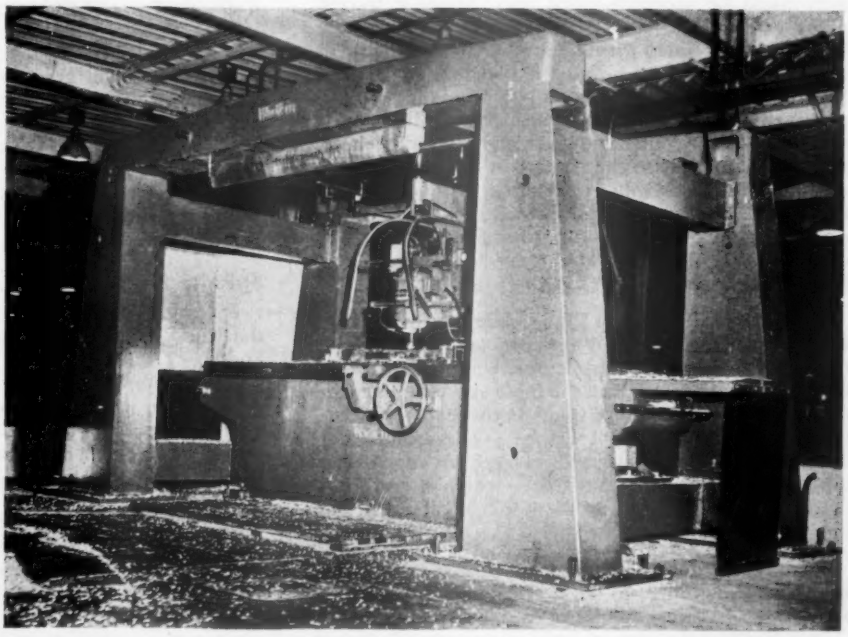


Fig. 3.

Fig. 4.

column of the router to get maximum rigidity and ensure continued alignment between the table and the top template carrier. This weight is essential as the guide pin may strike the template with force and with the weight of the moving radial arm behind it, substantial forces are set up and the template moved in relation to the table, which would of course affect the accuracy of the machine. The radial arm unit is similar to that illustrated in Fig. 1, except that a heavy bracket has been fitted on the horizontal radial arm to carry a follower pin on the same axis as the centre of the cutting spindle.

This machine was provided with a table 10′ 0″ long x 2′ 6″ wide arranged to traverse longitudinally, so that work longer than the compass of the radial arm could be accommodated and the table moved along as required. The table and the top template holder were jig bored with $\frac{1}{2}$″ template holes at 8″ spacing to act as universal pick up points for locating all Hydrotel existing profiling templates from the Cincinnati machines, the idea being to rough out all the suitable parts on the router and finish on the Hydrotel. It is a simple matter on the router, by varying the size of the guide pin or roller in relation to the cutter, to produce a component size or oversize to any required dimension on outside profiles and size or undersize on internal profiles so that the use of size templates for the roughing operation did not cause any difficulty.

In practice it has been found desirable to be able to move the top template along in tandem with the table and this arrangement is now being fitted to the machine in such a way that the table and template can be traversed independently, or both head and template can be traversed together. The positioning is done by dividing bars fitted on the front edge of the table and on the template carrier which is really an inverted table, and powerful plungers on the table base and top frames locate them.

With this arrangement it is now possible, by moving the table along once, to cover a component 10′ 0″ x 2′ 6″ using existing templates and by roughing out to $\frac{1}{32}$″ oversize to remove the excess material quickly and economically. In some applications it may be possible to finish out a component on this machine to about .005″ to .010″ depending upon the size and depth of the component.

A close-up of the head, profile plate, pin and roller can be seen in Fig. 4. The pin and cutter spindle must be maintained in the same vertical axis. The rise and fall of the follower pin to engage with the template is operated by a Bowden cable fixed on the right hand operating handle, and is quite good in practice. The cutter head is mounted on a " drop " slide, plunger-controlled for depth with the usual type of handle and links and, in addition, a second vertical slide is provided behind the drop slide with screw adjustment and handwheel on the left hand side of the operating position calibrated so that one turn gives a drop of $\frac{1}{8}$″.

I think it probable that a more efficient and cheaper way of handling long components would be to have a fixed table, say 12′ long and a fixed overhead template carrier, arranging the router radial arm to travel under power on a bed behind the table. The power is not to assist cutting, but to position the arm to cover 4′ x 2′ 6″ area on the table and then move the unit along the bed 4′ to cover the adjacent area on the component. In this way it is easier to maintain the radial arm in a horizontal plane on a substantial bed than the alignment of a travelling table and travelling overhead template carrier. A machine of this type is now being designed and is shown in Fig. 5. There are other features on this machine to which I shall refer again later.

I think it probable that the machine outlined above could make a good contribution to cost reduction of many components required for aircraft production, but there are several considerations which if practical would add very much to the potentialities of the method :—

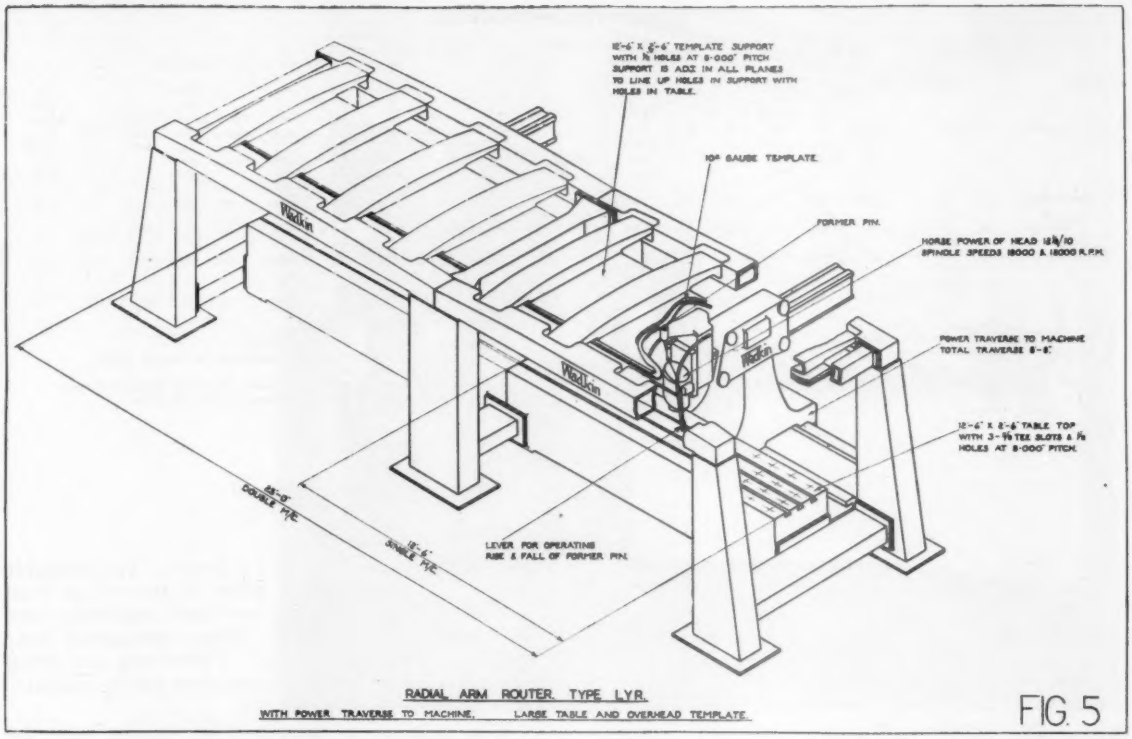
(1) The use of increased h.p. to the spindle, and a possible increased rate of metal removal ;

(2) the application of servo control ;

(3) the method of supporting the routing head, i.e. the radial arm.

Spindle Horse Power

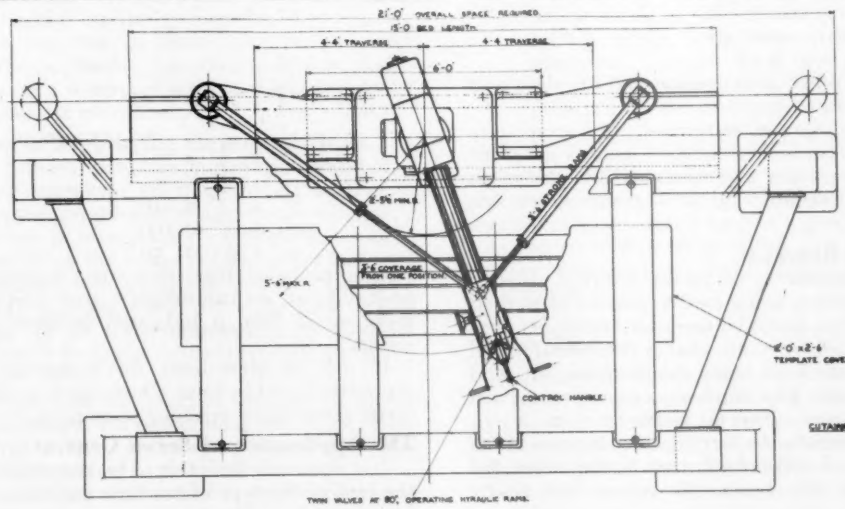
It soon became apparent on the prototype machine that the 5 h.p. head was not powerful enough for an operator's natural ability to move the head along when sinking pockets, or profiling above 2″ deep, and soon he was using it with care to prevent stalling on recessing using a $2\frac{1}{4}$″ diameter carbide cutter. A larger head of 10 h.p. was produced and this has been tried for the first time in the last few days with excellent initial results. This new head is almost three times as powerful as the 5 h.p. head and we are now designing a further head of 20 h.p. capable of well over double the power of the present new one. The powers of these heads are shown in the following table :—.

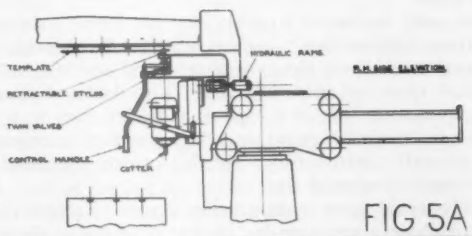

12'-6" X 8'-6" TEMPLATE SUPPORT WITH ⅞ HOLES AT 8·000" PITCH SUPPORT IS ADJ IN ALL PLANES TO LINE UP HOLES IN SUPPORT WITH HOLES IN TABLE.
10" GAUGE TEMPLATE
FORMER PIN
HORSE POWER OF HEAD 12½/10 SPINDLE SPEEDS 18000 & 18000 R.P.M.
POWER TRAVERSE TO MACHINE TOTAL TRAVERSE 8'-6"
12'-6" X 2'-6" TABLE TOP WITH 3-⅝ TEE SLOTS & ⅞ HOLES AT 8·000" PITCH.
LEVER FOR OPERATING RISE & FALL OF FORMER PIN.
Wadkin

RADIAL ARM ROUTER TYPE LYR.

WITH POWER TRAVERSE TO MACHINE. LARGE TABLE AND OVERHEAD TEMPLATE.

FIG. 5





WADKIN RADIAL ARM ROUTER. TYPE LYR.

MOUNTED ON BED & WITH HYDRAULIC CONTROL FROM OVERHEAD TEMPLATE.

FIG 5A

CUTTING TEST ON POCKETING

CUTTER 2½″ dia. T.C.T. — POCKET 8″ x 7½″ = 60 sq. ins. — L.Y.R. *with 5 h.p. head*

Material	Cut	Speed r.p.m.	Feed ins. per min.	Alloy Removed Cu. ins. per min.	Tooth Loading	H.P.	Cu.ins. Metal Removed per h.p.	
Noral.B26S or B.S.S.L.70 U.T.S.26 tons s.q./in.	2½″ dia. x 1/8″	12000	90	9.4	.0037	6.4	1.47	Optimum conditions Peak loads
	2½″ dia. x 1/8″	12000	98	10.2	.0041	6.3	1.62	
	2½″ dia. x .090″		Head stalls.					
	2½″ dia. x 1/16″	12000	127	6.6	.0053	5.1	1.3	

Pocket 1¼″ deep.
Average time for 1/8″ cut 22 seconds
Setting time for depth between each cut 10 seconds
30 cuts
Total machining time including each setting for depth 17.2 mins.
„ actual cutting time 11.8 minutes (9.5 cu.ins./min.)
„ metal removed 112.5 cu. inches.

As before but with 10 h.p. head

Material	Cut	Speed r.p.m.	Feed inches per min.	Alloy Removed Cu-ins. per min.	Tooth Loading	H.P.	Cu. Ins. Metal Removed per h.p.
As before	2½″ dia. x 1/4″	12000	33	13.8	.0013	11.9	1.16
	2½″ dia. x 1/4″	12000	32	13.4	.0013	12.2	1.1
	2½″ dia. x 1/4″	12000	31	12.9	.0013	11.3	1.14
	2½″ dia. x 1/4″	12000	25	15.5	.001	13.5	1.15

Pocket 2″ deep
Average time for 1/4″ cut 1 min. 8 secs.
Setting time for depth between each cut 34 secs.
8 cuts
Total machining time including each setting for depth 13.6 mins.
„ actual cutting time 9.06 mins. (13.3 cu.ins./min.)
„ metal removed 120 cu. ins.

For sketch of this test see Fig. 8 and cutter detail Fig. 7.

Speed	12,000	18,000	24,000
2 h.p. head used for sheet work		1½ (4)	2 h.p. (6)
2 h.p. head	3⅓ (7)	5 (12)	—
10 h.p. head (on test)	10 (21)	12½ (25)	—
50 h.p. head being designed	20 (not yet known but about 40 h.p.)	—	—

Approx. h.p. immediately before stalling, shown in brackets below rated h.p.

It is difficult to rate continuously the exact h.p. available on these high frequency motors as much depends on the cooling arrangements, but the ratios of the power available in the various heads are correct.

Rate of Metal Removal

In any consideration of metal removal, that is where the machine is being used to remove unwanted alloy as quickly as possible, we must remember that the machine is fed by hand, that is the operator just pulls or pushes the head along the template line, and we do not yet know how much power an operator can control in this way. We do know that on the 10 h.p. head the operator by forcing the cut was able to stall the head and still hold it, that is, the cutter did not jump. At this point, the motor was giving 22 h.p.

It may be useful to give in table form a series of cutting tests on the 5 and 10 h.p. heads, showing the actual cuts taken, the power required and the rate of metal removed per minute. The latter figure is important as this of course is a major factor in the floor to floor time on many components now required in aircraft construction. All the figures are based on averages of several tests.

The table gives comparative figures of times taken to produce a rectangular pocket 8″ x 7½″ x about 2″ deep with the 5 h.p. and 10 h.p. heads. It is probable that if 1/8″ cuts had been taken on the 10 h.p. head instead of 1/4″ that a cutting rate of 90″ could have been maintained and a much better production time shown on the bigger heads. These tests are being repeated and additional information will be available in due course. (*see page* 223).

It is possible to take cuts as follows with the 5 h.p. head :—

1″ deep x 1/8″ at 100″ per minute
1″ „ x 1/16″ „ 160″ „ „
3″ „ x 1/32″ „ 100″ „ „
4½″ „ x 1/32″ „ 100″ „ „

On the 10 h.p. heads the figures are as follows :—

1″ x 1/4″ at 66″ per minute
1″ x 3/8″ at 64″ „ „
1″ x 1/2″ at 55″ „ „
1″ x 5/8″ at 48″ „ „
3″ x 1/16″ at 100″ „ „
4½″ x 1/16″ at 50″ „ „

It is probable that after some experience of the 10 h.p. head, we can design cutters that will remove more metal than is indicated in these preliminary results.

It will be seen from the foregoing that these represent sizeable cuts which give a high rate of metal removal for profiling operations.

The Application of Servo Control

It is obviously desirable to be able to power control the feed of this type of machine and this is now being investigated. The most promising method is the use of two cylinders at right angles anchored on the supporting columns of the overhead template on the fixed column machine shown in Fig. 3. Their intersection point can be anchored immediately behind the cutter spindle axis and the amount of error involved would probably not be serious. The same idea is illustrated in Fig. 5A and is shown with the entire hydraulic mechanism self-contained and travelling on a bed at the rear of the machine, so that a fixed table and fixed overhead template can

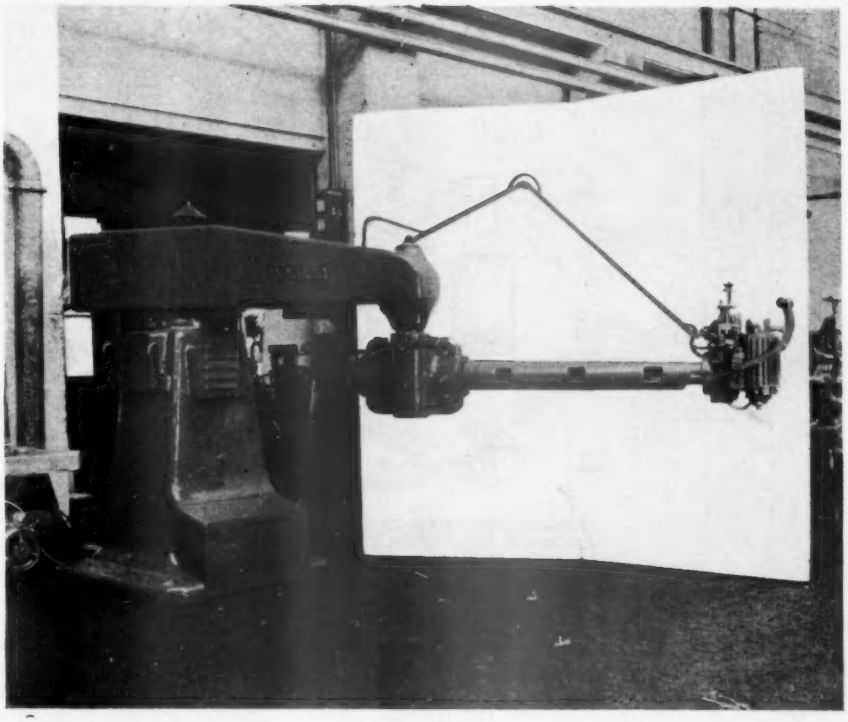


Fig. 6.

be used. With this method, a plate 12′ 6″ x 2′ 6″ in area or 3′ 0″ x 2′ 6″ can be covered and by coupling up two units together an area 25′ 0″ x 2′ 6″, and the way is then open for components of any length up to 2′ 6″ wide. Reference back to Fig. 5 will make this point clear.

The Method of Supporting the Router Head

We have hitherto used the horizontal sliding arm on a rotating barrel for all standard application of the radial router and this has been generally successful. Now, however, it is necessary to work to as close limits as possible on the bottom of the cutter in a true horizontal plane for finishing the bottoms of pockets and face milling crank cases, etc. To achieve this there appear to be three alternatives to consider before being able to decide on the best type for heavy routing :

(*a*) using the type we have, to improve its mechanical design, by redesigning the frame, arm and suspension to get increased accuracy. This is now being done.

(*b*) experimenting with a double arm radial using precision preloaded bearings.* This type, of course, has been in general use in the United States for many years, and whilst tried in this country has not been used on a wide scale. We have designed a test machine of this type for experimental investigation and it should be test operating in the next two or three weeks. The advantage of this arrangement is that it is possible to get a bigger radius of action than our present machine, although we do not yet know the sag on the cutter point.

(*c*) a gantry type, comprising a fixed table, with beams on either side of the table, supporting a rolling girder across the work on which is mounted a router head moving across the girder. Such a machine is being used at the present time for some applications.

(*d*) A combination of (*a*) and (*b*) as in Fig. 6.

This type of machine was made and used in the airframe industry for big reach work on built up sheets, years ago, and it may be a good way of getting a big reach with a short sliding arm, using a much heavier construction than that shown in the photograph.

Cutter Design

A range of cutters has been designed for this machine, but it seems probable that they will be continuously modified as the power of the head is increased and probably again when servo control is applied. It will be appreciated that sometimes it is policy to sacrifice efficiency to get free cutting on a hand-fed operation and this would not be necessary on power feed. All pocketing cutters are tungsten-carbide tipped. Short profiling cutters up to about 2½″ long of the straight flute pattern cut more freely than the quick spiral, but cannot be held up to the template above this depth (2½″). Above this up to the present maximum of 4½″, a quick spiral gives smoothest cutting and best results.

A typical pocketing cutter 2¼″ diameter T.C.T. is illustrated and also a spiral mill 5″ long for profiling work, in Fig. 7.

* See Fig. 6A, page 223.

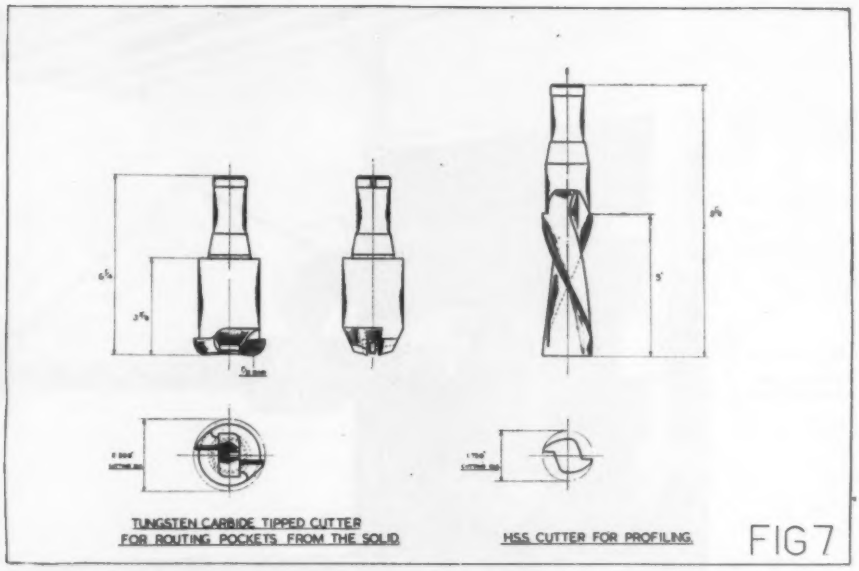
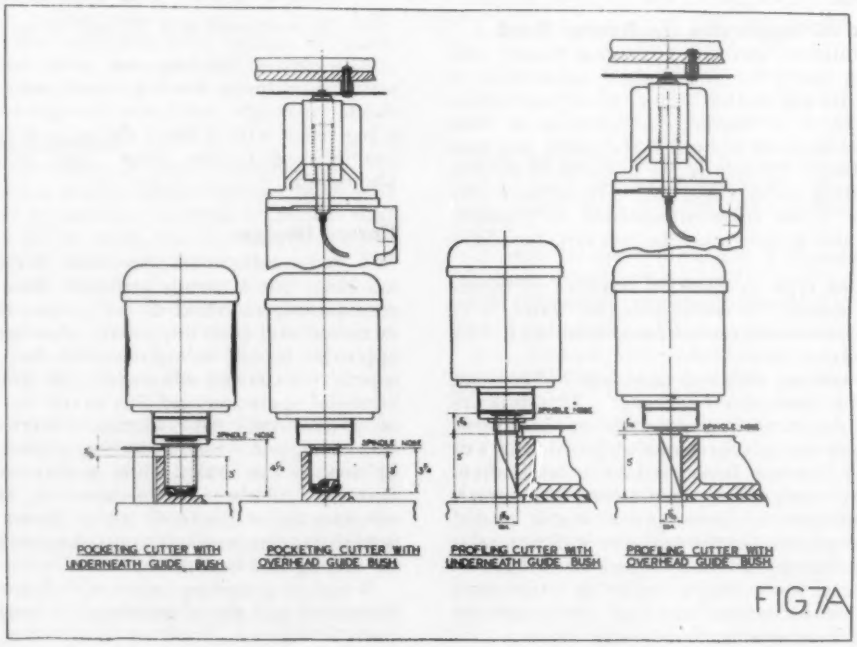
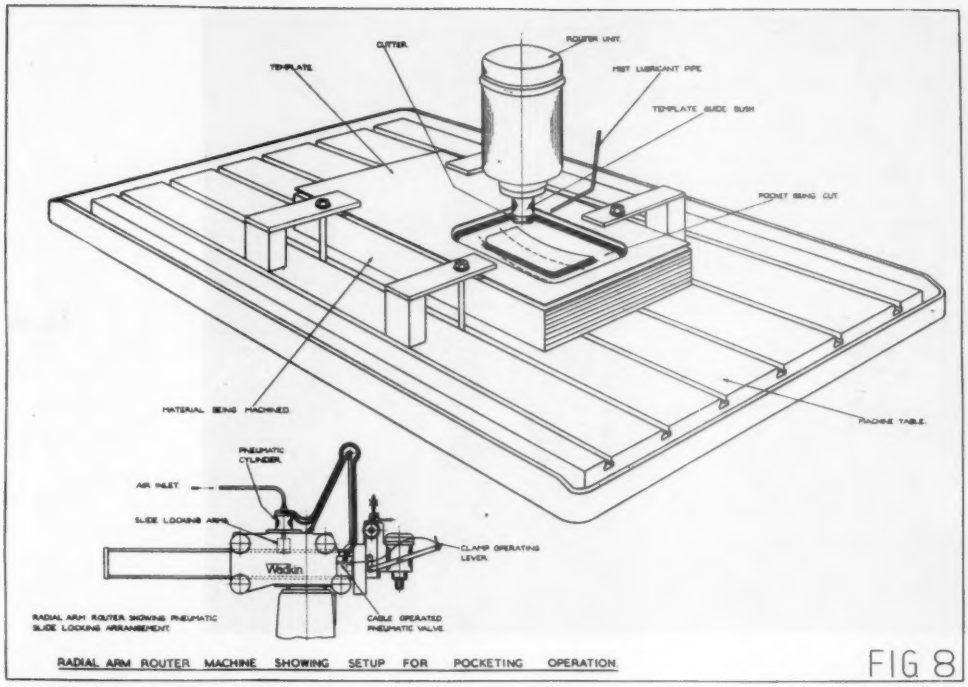


Fig. 7A shows the advantage of dispensing with the guide bush around the cutter and using the overhead template on both types. Note that the cutters are located directly in the taper bore of the spindle, secured by a draw bolt through the spindle. For small cutters up to 1″ diameter and 1½″ long collets can be used with parallel shank cutters, up to a maximum of ⅞″.

Method of Working

The methods of profiling are quite straightforward, as is the cutting out of 1″ thick sheet. The new problem is the cutting of large internal pockets. Here again, the profiling of the pocket is straightforward but the removal of the metal in the centre of the pocket without a guide can be slower than when using a guide plate. In order to eliminate this difficulty, we have fitted an air operated lock to the sliding arm, which gives the equivalent of a radial guide template which speeds up the operation appreciably; the operator, using a 2½″ diameter


POCKETING CUTTER WITH UNDERNEATH GUIDE BUSH
POCKETING CUTTER WITH OVERHEAD GUIDE BUSH
PROFILING CUTTER WITH UNDERNEATH GUIDE BUSH
PROFILING CUTTER WITH OVERHEAD GUIDE BUSH
FIG 7A



RADIAL ARM ROUTER MACHINE SHOWING SETUP FOR POCKETING OPERATION

FIG 8

cutter, sweeps radially from left hand side of the template to the right, draws out the radial arm about 2" and relocks sweeping from right to left, and so continues until the centre area is cleared as shown in Fig. 8. The air lock release is operated by a press button on the operating handle so that no time is lost in this operation.

Lubrication

The lubrication of high speed cutters has always been a problem which hitherto we have solved by applying the lubrication by brush to the part to be routed. A tacky mixture of paraffin, soluble oil and old engine oil has given good results.

In view of the rate of metal removal possible with more powerful heads brushing is too slow and an oil mixture and a jet of compressed air have been used experimentally and have proved very satisfactory. Both the oil volume and the air pressure are variable at the operating position and satisfactory oil mist lubrication can be obtained for all types of cutters.

The use of a small amount of molybdenum disulphide at about 1 in 500 has given very good results and cutting oils containing the sulphide, suitable for routing duty, are available.

Cutter Life

It is difficult, as yet, to give precise details of cutter life that can be obtained. We are still using some high speed steel spiral cutters for profiling, but these will soon be replaced by spiral carbides. All other cutters are carbide and pocketing cutters using molybdenum disulphide lubricants are running continuously for over a week on production without being touched or removed by the operator.

It appears that with the increased power available, hand honing of the cutters is not so important, and good machine finishing should be quite enough, for good working at 12,000 r.p.m.

Skin Milling

It is possible that routing may have some application on skin milling. Mr. Woodley, of Vickers Supermarine, described such a machine based on two radial routers specially arranged which was at that time under construction. I am pleased to be able to report that this machine is now satisfactorily producing skins, by hand operation to the profile in two dimensions.

A photograph of the machine and a skin produced on it are illustrated in Figs. 9 and 10. On this machine two special radial arms are used, one on each side of the table to cover a skin 6 feet wide, and any length can be handled by moving up. The arm is supported on a ball bearing gantry, to eliminate any sag of the head and accurately controls the depth over an area of 3′ x 3′. The operator is mounted in a chair, bridge mounted across the work with power forward and reverse to it, operated by foot pedals, shown in Fig. 11. In this way, the operator is always close to his cutter and has a comfortable operating position. With this equipment it is possible to get skin thickness to about ±.002" over an area of 30" x 30", using of course vacuum chucks on the table. A finished skin produced on this machine is shown in Fig. 11.

Another method of dealing with this problem is being considered incorporating power feed and compressed air loading of the follower pin to the template is shown in Fig. 12.

The machine is based on the gantry principle,

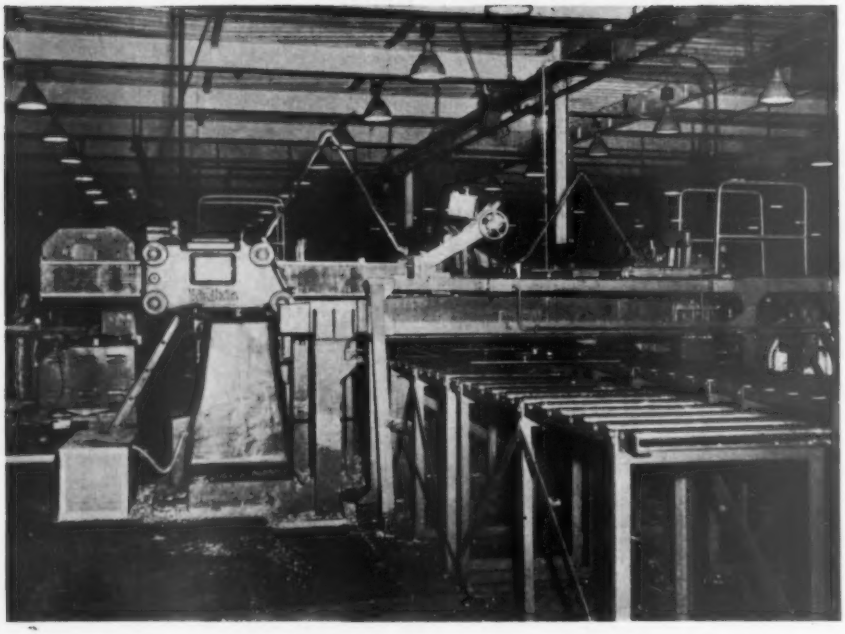


Fig. 9.

fixed table and an overhead gantry carrying a cross slide on which is mounted a router head of 20 h.p. Power feed is provided along the length working in conjunction with double acting pneumatic cylinders at right angles to the feed to keep the guide roller up to the profile plate. Similar feed is provided across the table with pneumatic hold ups, so that the operator using 2-4 way switches on the travelling gantry can follow the profile roller by manipulating the switches, This application is of course only two dimensional, but it represents a step forward in getting power feed to a skin of 16′ x 5′ size at a modest cost. Because only a router is used the stresses set up in the machine will be small and a relatively light construction will give the required accuracy.

By using a series of superimposed templates, stepped pockets can be obtained and a tapered skin be obtained by suitable packing on the table.

New Universal Milling Machine

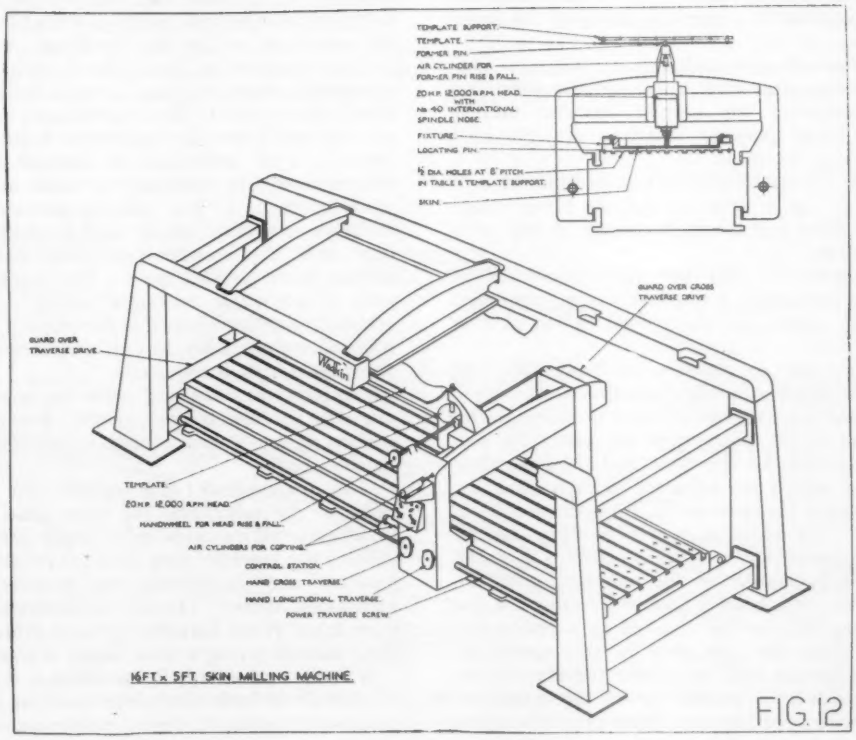
Whilst a great deal can be done in aircraft production by the routing methods already described, I recognise that there is a great need for three-dimensional milling at a fast rate on a machine capable of taking large components and the larger it is, the more useful it is to the production engineer.

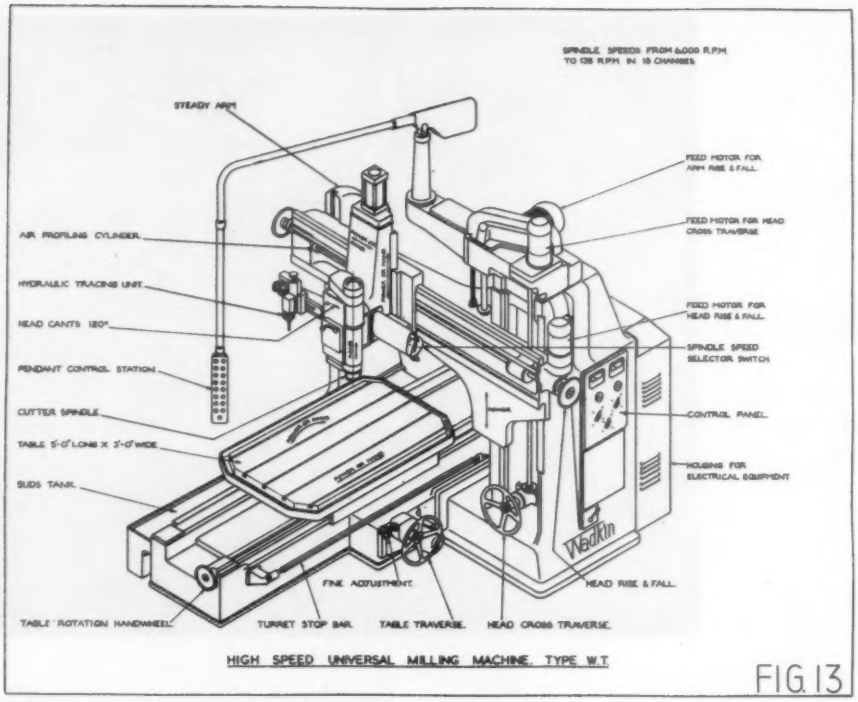
The machine illustrated in Fig. 13 has been designed for light alloy cutting and the prototype will be finished in the next few weeks. It is an open-side design capable of high feeds and speeds.

The longitudinal traverse is on the table, the cross traverse of the cutter head on the cross beam. In addition the table has power feed rotation, and the spindle head cants through 120° from 15° left through vertical to 15° below horizontal right. The spindle

Fig. 10.

Fig. 11.


TEMPLATE SUPPORT
TEMPLATE
FORMER PIN
AIR CYLINDER FOR FORMER PIN RISE & FALL
20 H.P. 12,000 R.P.M. HEAD WITH No 40 INTERNATIONAL SPINDLE NOSE
FIXTURE
LOCATING PIN
½ DIA. HOLES AT 8" PITCH IN TABLE & TEMPLATE SUPPORT
SKIN
GUARD OVER TRAVERSE DRIVE
GUARD OVER CROSS TRAVERSE DRIVE
TEMPLATE
20 H.P. 12,000 R.P.M. HEAD
HANDWHEEL FOR HEAD RISE & FALL
AIR CYLINDERS FOR COPYING
CONTROL STATION
HAND CROSS TRAVERSE
HAND LONGITUDINAL TRAVERSE
POWER TRAVERSE SCREW
16 FT. x 5 FT. SKIN MILLING MACHINE.
FIG. 12



HIGH SPEED UNIVERSAL MILLING MACHINE. TYPE W.T

FIG. 13

is quill mounted, having $3\frac{1}{2}$" of down feed, so that angular boring and milling can be done, in addition to 12" of power feed in a vertical plane on the intermediate slide.

The machine will take work up to 5' long x 3' wide x 3' high or circular work up to 5' diameter and up to 7' diameter for simple circular milling operations. Eight plunger locations are provided at 45° for setting the table.

The spindle headstock has a 5 h.p. head fitted with 18 speeds from 135 - 6,000 r.p.m., the lower range through gear drive and the higher range on belt with no gears in mesh.

Power traverses 6" - 180" per min. are offered on table traverse and rotation $^1/_{30}$ to 1 r.p.m., cross feed to spindle (3" - 90") and down feed ($\frac{1}{2}$" to 12") to spindle.

Capstan stop bars are fitted to all head and table movements for small quantity repetition work.

The machine is arranged for hand profiling, using a profile plate on the component and using the two traverse handwheels for the table and the cross slide of the spindle, which are adjacent to each other for the convenience of the operator in this operation up to about 5' x 5'. In addition, power profiling can be done, using a pneumatic control in order to keep the cutter follower mounted on the spindle up to the template. The cutterhead is arranged to float on the horizontal arm and can be coupled to a pneumatic cylinder built into the arm itself for this operation. By using this device and the down traverse of the table, it is possible to profile up to the length of the machine with a variation in depth of profile of the stroke of the pneumatic cylinder which is 9". Alternatively, the rotating table can be used for work of a fairly circular nature (up to 9" variation of radius) in the same way as for 360° profiling.

The machine is also offered with hydraulically controlled depth copying, a stylus attachment being fitted side by side to the cutterspindle on the horizontal arm and when this equipment is used components up to 5' x 18" wide can be worked on the table. Alternatively, by turning the table at right angles work up to 2' 6" x 3' can be accommodated. In addition, the tracer can be used vertically in conjunction with the spindle positioned horizontally for milling short profiled spars. The machine is offered with a removable outboard steady and it will be appreciated that when this is removed, the machine is open on three sides, so that very large limbs can be accommodated as required.

Double rotary copying tables for work up to 2' 6" diameter are also offered, power operated, for applications where a rotary feed is preferable to longitudinal feed.

The longitudinal table traverse, the rotary movement of the table and the cross slide carrying the spindle are all mounted on multiple precision rollers, making the machine very light to operate on the hand traverse and facilitating the profiling operations mentioned above. The power traverses are obtained from small Ward Leonard sets and infinitely variable D.C. motors giving a wide range of feed speeds.

A further advantage in operation is the duplication of controls on both sides of the machine and, with the swing-over pendant, the operator working from one

side or the other can always be close to the cut which he is making so that he can see clearly exactly what he is doing ; in addition, he can if he wishes, index his table through 180°, and continue without changing his operating side. The machine is equipped with oil mist for cutter lubrication if required.

Spar Milling Machines

The spar milling technique in this country has been given a boost in the last few years by the importation of high speed American millers. The use of smaller diameter cutters, say about 8″ and with a high speed of 3,000 r.p.m., is a tendency to go back to woodworking practice. I recently turned up some old notes and find that on a test run in 1940 we used a standard stock woodworking cutterhead, 8″ diameter, 1 $\frac{13}{16}$″ bore, fitted with two stellite tipped steel bits running at 2,000 r.p.m. to gap a 2″ x 2″ channel from the solid at 24″ per minute and taking 41 h.p. This is in line, I consider, with present day practice on spar milling machines in this country.

The introduction of the rocking horizontal head is a very useful feature but the manner in which it has been done is not entirely satisfactory, because of the position of the pivoting point of the cutterspindle assembly not being on the cutting edge of the cutter, making for complicated copy bar calculations before their manufacture. In addition, the use of pneumatic hold-downs to cant the spindle to the copy bars creates a big pressure on the copy bars themselves and these have to be of robust construction to withstand the pressure of the hold-down rollers.

The introduction of the canting vertical spindle is of advantage for many types of spars although it is of course an added complication to the machine.

Fig. 14 illustrates a new spar milling machine which is being prepared specifically to meet the needs of the British aircraft industry. It has been decided to abandon the openside construction and make it bridge type to get additional rigidity. On the other hand, the outboard arm is easily removable for occasional work of large size where the steady would be in the way. The pivot point of the canting horizontal spindle has been chosen with care to make the design calculations of the canting copy bar as simple as possible and reference to the section drawing, Fig. 15, will, I think, make this clear. Vertical and horizontal slides in front of the canting slide mechanism make it possible to position the bottom centre cutting point of the cutter to the correct datum point, to compensate for loss of cutter diameter due to cutter grinding and other factors. It is proposed that the canting and rise and fall mechanisms should be controlled by two independent hydraulic servo mechanisms which will keep the copy bars light and simple as possible. Provision is made for carrying the copy bars at the rear of the machine, a set of three being necessary for profile and cant of the horizontal and cant of the vertical spindle.

The horizontal spindle will be equipped with a change pole motor direct on the spindle, giving 60 h.p. at 3,000 r.p.m. down to 10 h.p. at 750, and a reduction gear is also fitted to give a range of speeds of 30 up to 500 r.p.m. on a second spindle. It is recognised that with the possibility of steel spars having to be considered that any spar milling machine today should be capable of cutting high tensile steel as well as aluminium, and this machine should do both in a satisfactory manner.

The machine is also offered with a vertical router spindle, shown on Fig. 16, canting 10° forward and backwards about the centre of the cutting edge of the cutter. The spindle unit will be equipped with 20 h.p. at 10,000 r.p.m. The unit is mounted on the main horizontal spindle headstock, so that it will rise and fall as required on the main servo. The unit is

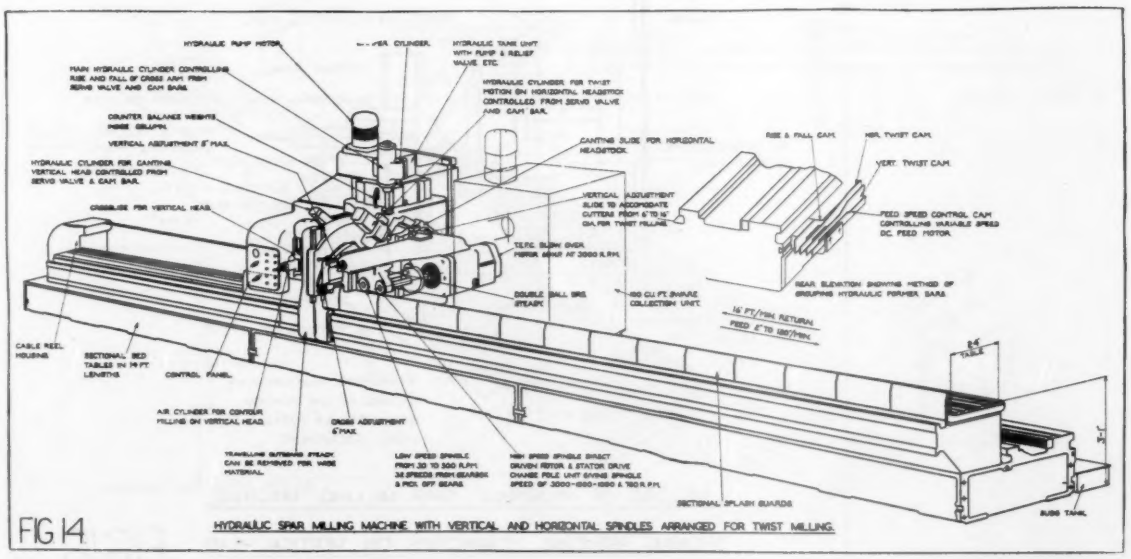
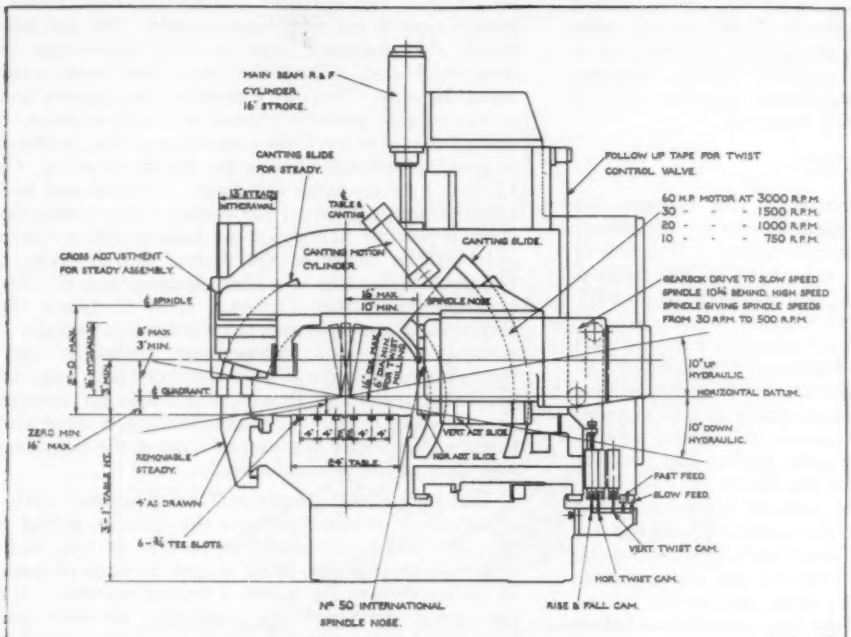
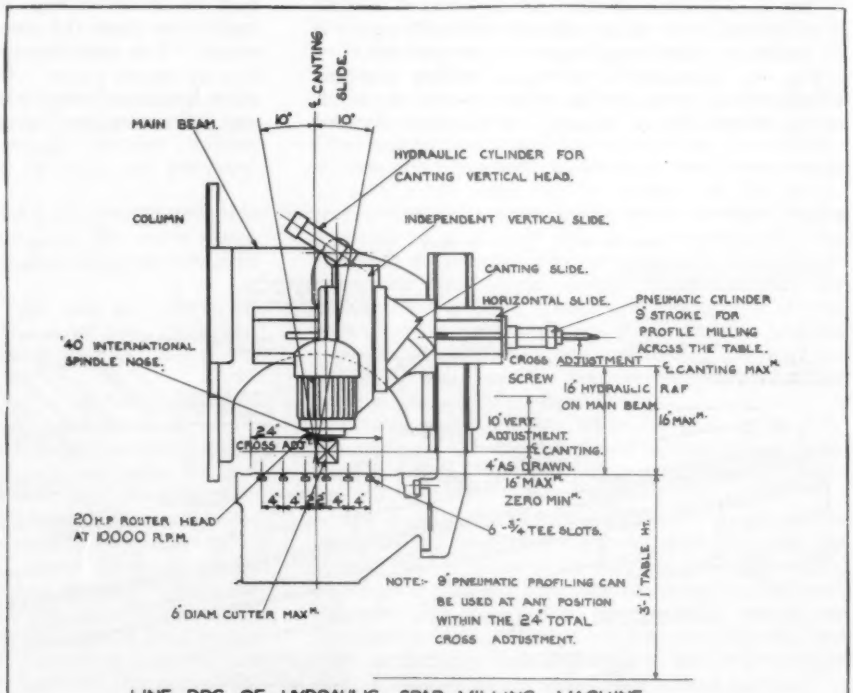

HYDRAULIC PUMP MOTOR
HYDRAULIC TANK UNIT WITH PUMP & RELIEF VALVE ETC.
MAIN HYDRAULIC CYLINDER CONTROLLING RISE AND FALL OF CROSS ARM FROM SERVO VALVE AND CAM BARS
HYDRAULIC CYLINDER FOR TWIST MOTION ON HORIZONTAL HEADSTOCK CONTROLLED FROM SERVO VALVE AND CAM BAR
COUNTER BALANCE WEIGHTS
VERTICAL ADJUSTMENT 6" MAX.
HYDRAULIC CYLINDER FOR CANTING VERTICAL HEAD CONTROLLED FROM SERVO VALVE & CAM BAR.
CANTING SLIDE FOR HORIZONTAL HEADSTOCK
RISE & FALL CAM.
HOR. TWIST CAM.
VERT. TWIST CAM.
VERTICAL ADJUSTMENT SLIDE TO ACCOMODATE CUTTERS FROM 6" TO 16" DIA. FOR TWIST MILLING
FEED SPEED CONTROL CAM CONTROLLING VARIABLE SPEED D.C. FEED MOTOR
REAR ELEVATION SHOWING METHOD OF GROUPING HYDRAULIC FORMER BARS
16' FT/MIN. RETURN
FEED 6" TO 180"/MIN
CABLE REEL HOUSING
SECTIONAL BED TABLES IN 10 FT. LENGTHS
CONTROL PANEL
AIR CYLINDER FOR CONTOUR MILLING ON VERTICAL HEAD
CROSS ADJUSTMENT 6" MAX.
TRAVELLING OUTBOARD STEADY CAN BE REMOVED FOR WIDE MATERIAL
LOW SPEED SPINDLE FROM 30 TO 500 R.P.M. 24 SPEEDS FROM GEARBOX & POL. CHT. GEARS
HIGH SPEED SPINDLE DIRECT DRIVEN ROTOR & STATOR DRIVE CHANGE POLE UNIT GIVING SPINDLE SPEED OF 3000-1500-1000 & 750 R.P.M.
SECTIONAL SPLASH GUARDS
SUMP TANK

FIG 14 HYDRAULIC SPAR MILLING MACHINE WITH VERTICAL AND HORIZONTAL SPINDLES ARRANGED FOR TWIST MILLING.


MAIN BEAM R & F CYLINDER. 16" STROKE.
CANTING SLIDE FOR STEADY.
FOLLOW UP TAPE FOR TWIST CONTROL VALVE.
60 H.P MOTOR AT 3000 R.P.M.
30 " " " 1500 R.P.M.
20 " " " 1000 R.P.M.
10 " " " 750 R.P.M.
CROSS ADJUSTMENT FOR STEADY ASSEMBLY.
CANTING MOTION CYLINDER.
CANTING SLIDE.
GEARBOX DRIVE TO SLOW SPEED SPINDLE 10¾" BEHIND HIGH SPEED SPINDLE GIVING SPINDLE SPEEDS FROM 30 R.P.M. TO 500 R.P.M.
SPINDLE NOSE
10" UP HYDRAULIC.
HORIZONTAL DATUM.
10" DOWN HYDRAULIC.
ZERO MIN. 16" MAX.
REMOVABLE STEADY.
VERT. ADJ. SLIDE.
HOR. ADJ. SLIDE.
24" TABLE
FAST FEED.
SLOW FEED.
4" AS DRAWN
6 - ¾ TEE SLOTS.
VERT. TWIST CAM.
HOR. TWIST CAM.
RISE & FALL CAM.
Nº 50 INTERNATIONAL SPINDLE NOSE.

LINE DWG. OF HYDRAULIC SPAR MILLING MACHINE
SHOWING PRINCIPAL CAPACITIES RELATING TO THE HORIZONTAL SPINDLE HEADSTOCK.

FIG. 15.



LINE DRG OF HYDRAULIC SPAR MILLING MACHINE,
SHOWING PRINCIPAL CAPACITIES ON VERTICAL HEAD.

FIG.16.

also equipped to move forward and backwards from the operating position to give in and out copying up to 9″ pneumatically controlled, the pressure required being very small because of the router speed of the spindle. From this, it will be seen that three copy bars can be used on this head to rise and fall (hydraulic), move in and out (pneumatic) and to cant (hydraulic).

The machine is equipped with a table 24″ wide, which is new to this country, so far as I know for British built machines. I think that the best method is to follow the American standard for spar mills for this table width.

There is one point that is worthy of further consideration and that is, the question of upcutting or downcutting on the horizontal spindle. If the machine is required for downcutting, in the majority of cases there may be distinct advantages in building the machine the opposite hand to that shown in the illustration, so that the horizontal cutterhead is on the left hand side or the extreme left hand of the headstock looking at the front of the machine. This on downcutting would of course greatly facilitate the exhausting of chips on the machine. It also means that the vertical spindle would be in advance of the horizontal which may on occasion be a disadvantage. The question of swarf exhaust is a real problem and on small quantity production, where changeovers are taking place fairly rapidly, the use of special hoods for each operation can be a costly item and in practice does not get carried out.

There is a further addition to the spar mill that I think worthy of consideration and that is, the addition of a radial arm router unit mounted on a power operated travelling saddle on the machine bed. With this unit and drop on templates on to the spar mill fixtures, tapering operations and possibly additional pocketing operations could be carried out at the one setting of the spar.

The machine is arranged so that it can be made to any length, and added to after installation if necessary.

Spar mills are expensive machines and a point arises whether it is worthwhile to have two types of spar mill :

(*a*) the universal machine as illustrated.

(*b*) the simple, single spindle machine, fitted with hydraulic rise and fall only without twist or vertical spindle.

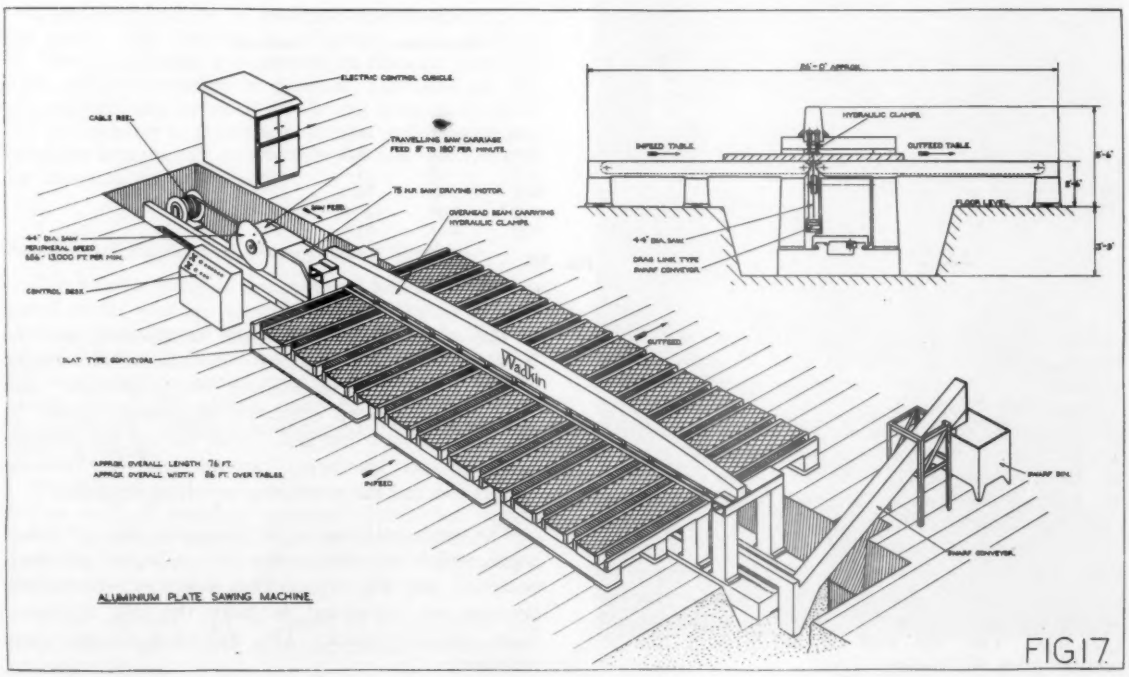
The universal machine will cost very considerably more than the single spindle machine and it may be policy, in a plant employing six machines, to use machines of each type, rather than pay the extra to have all machines universal.

Sawing of Alloy Billets

The demands of the airframe designer for large thick skins has repercussions in the rolling and extrusion mills, where a big capital cost is involved in installing equipment capable of producing the large heavy sheets.

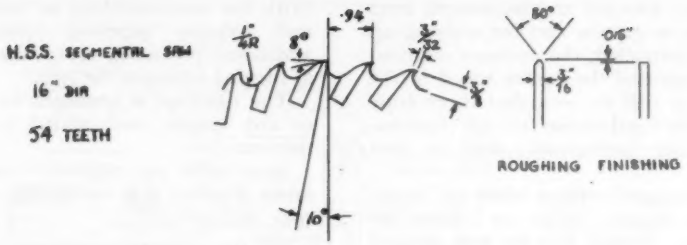
Fig. 17 illustrates a general outline of a large sawing machine which will be made in the immediate future to handle billets 45′ long x 10′ wide and up to 5″ thick. The machine will operate with carbide tipped saws 44″ diameter driven by 75 h.p. and feeds up to 10 ft. per minute.

The material is fed into the machine on conveyors arranged in three banks, separately controlled as required, so that the material can be manoeuvred



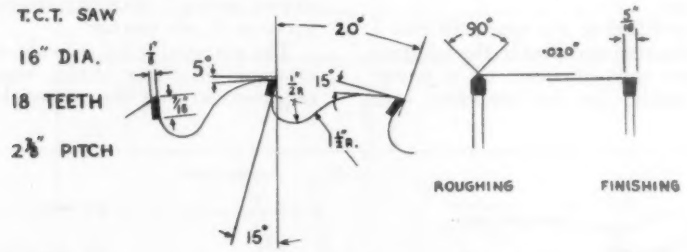
ALUMINIUM PLATE SAWING MACHINE.

FIG 17.



MATERIALS: NORAL 275 Aluminium alloy 4½" thick, 12' long.

Spindle Speed r.p.m.	*Peripheral Speed Ft. per min.*	*Feed Speed ins. per min.*	*Tooth Loading inches*	*Spindle h.p.*	*Feed h.p.*	*Remarks Cu. ins. of Metal Removed Per min.*	*Cu. ins. per min. per h.p.*
125	525	8	.0006	7	.35	6.75	.96
125	525	12	.0009	7.5	.47	10.1	1.35
225	945	12	.0005	7	.47	10.1	1.45
225	945	15	.0006	7	.55	12.7	1.82
200	840	10	.0005	6.45	.39	8.5	1.3
200	840	12	.0005	8.2	.47	10.1	1.23
200	840	16	.0007	9.8	.59	13.5	1.38
300	1260	18	.0005	11.4	.71	15.2	1.33
300	1260	22	.0006	12.9	.78	18.6	1.44
300	1260	24	.0007	14.1	.82	20.1	1.43
600	2520	34	.0005	15.9	1.15	28.7	1.87
600	2520	38	.0006	20.6	1.3	32.0	1.56
700	2940	48	.0006	32.5	1.57	40.5	1.25
1100	4600	59	.0005	35.6	1.97	50.0	1.41



450	1890	8	.0005	5.25	.35	11.3	2.16
650	2720	13	.0006	8.25	.49	18.3	2.22
650	2720	22	.0009	10.7	.78	31.0	2.9
1700	7150	60	.0010	26.5	1.46	84.2	3.18
1800	7550	100	.0015	42.9	1.98	140.0	3.26
1900	7950	116	.0017	42.9	2.25	163.0	3.8

Fig. 18.

into alignment for sawing. The offcut is removed in the same way either sideways from the saw carriage as illustrated or down the mill (in line with the machine bed) to suit the mill layout.

Preliminary tests to establish design data for this project were done on a spar mill, and the results of the tests are given in Fig. 18.

The first chart shows a series of tests on a 16" segmental H.S.S. saw .94" pitch, compared with a 16" diameter carbide tipped cutter, ¼" thick in the body and $\frac{5}{16}$" across the tips. An interesting point to notice is the good performance of the segmental saw at 59" per minute, at 1,100 r.p.m., absorbing 35.6 h.p. This was well beyond what I thought possible on a 16" blade.

The carbide saw was quite satisfactory, and in line with our expectations. Because of the larger gullet, a bigger tooth loading was permissible and thus gave increased efficiency in cutting, shown in cu. ins. removed per h.p. The test on the carbide saw was not continued beyond 116" per minute as this covered the maximum we thought useful.

The next test was a 32" diameter saw, 3" pitch teeth, which we tried on the spar miller on 9½" deep material (see Fig. 19). This saw size was chosen because we happened to have the saw available from wartime stock. The following figures were obtained :

TEST SAWING.

Material : Noral M75S—DTD 687A. U.T.S. 32 Tons/sq. in.
3′ 4″ lnog × 9½″ deep.
Saw : 32″ dia. 32 teeth. T.C.T. 15° hook. 50° top clearance. 3.1″ pitch.

Spindle Speed r.p.m.	*Peripheral Speed ft. per. min*	*Feed Ins./Min.*	*Tooth Loading*	*Spindle h.p.*	*Feed h.p.*	*Cu. ins. of Metal Removed per min.*	*Cu. ins. of Metal Removed per h.p.*
850	7120	30	.0011	29.6	1.09	89	3
820	6870	35	.0014	31.6	1.43	104	3·3
820	6870	35	.0014	31.2	1.2	104	3·3
800	6700	42	.0014	37.	1.56	125	3·4
775	6500	45	.0018	40.	1.72	133	3·3
800	6700	50	.002	42.4	1.68	148	3·5
750	6300	52	.0022	44·5	2.76	154	3·5
750	6300	56	.0024	47·	2.16	166	3·5
Material : Noral 2S 99.5% pure Alum. (B.S.S. 1477 PIC)							
900	7550	14	.0005	43	·45	38	
Saw stalled due to clogging of saw teeth.							

Whilst the cutting of the harder material was satisfactory, the pure aluminium packed the saw, and further tests are taking place using a coarser pitch of tooth and a different cutting angle, to try and get a saw to cut these two extremes of material and save saw changing.

The large saw (44″ diameter) is necessary on this machine, because of the need to build a cantilever support to the material being cut; reference to the section of the machine (top right, Fig. 17) will make this clear. The clamping is done by a series of hydraulic units built into a bridge type beam.

The exhausting of the swarf is done by a drag link conveyor capable of removing 120 cu. ft. of swarf per hour, running on to a belt elevator to lift the swarf from the pit into mobile bins.

A problem still to be settled is the sharpening of the saws. The best results, of course, are achieved by using a grinding attachment on the saw machine with the saw mounted in position, but until the life of a carbide saw between grinds has been established it is not possible to determine whether grinding on the machine is economic or whether the saw will have to be removed for sharpening.

Sawing of Expanded Honeycomb Section

The band sawing of this material has been investigated in the past few months and after many failures we find that a taper saw section as shown in Fig. 20 (top left) gives best results. The teeth require to be be sharp and square-faced and run at a speed of about 8,000′ per minute or more. We have been successful in cutting unsupported material up to about 9″ deep.

The bigger problem is to make cuts 4′ 0″ or more across and, if possible, generate controlled curves for shaping the material to aerofoil sections. To facilitate this, the work is probably best done using a horizontal saw and is illustrated in Fig. 20.

If the material can be boxed in a container, the additional rigidity will help the cutting action very considerably.

On high speed bandsawing, the bigger the wheels the better the results and the blade life, whilst on a design of floating wheels it is obvious that the smaller the wheels, the better, and a compromise will have to be settled to meet both conditions.

Referring to Fig. 20, the material is mounted on a fixed table, if possible in a frame, and the horizontal blade traversed over the material, controlled by two cams giving the required shape. The type of finished component visualised is shown in the inset.

The Future

In this Paper, I have tried to give a detailed account of the progress on a few machine tools made

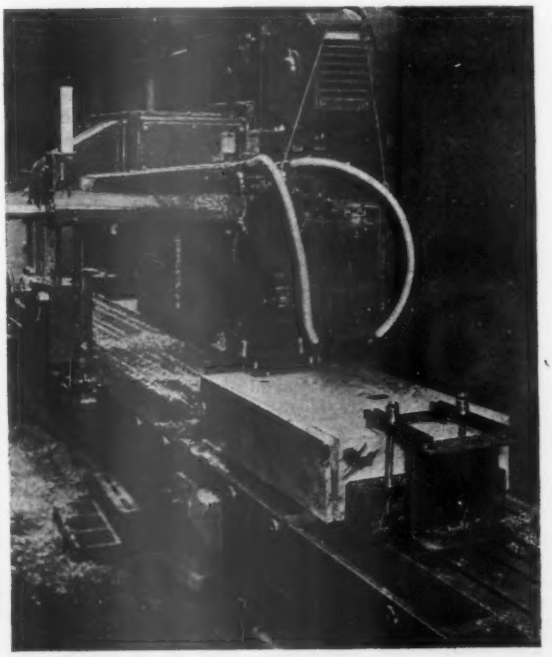
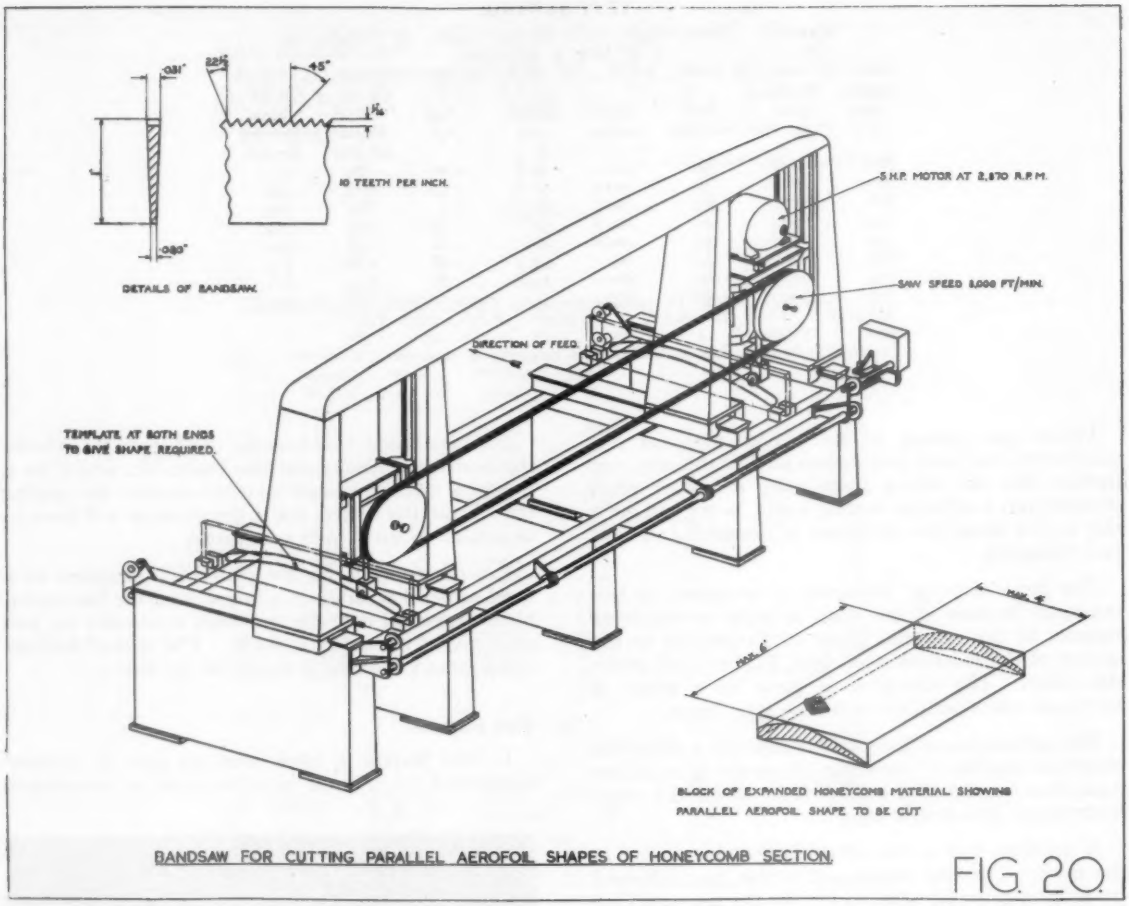


Fig. 19


10 TEETH PER INCH.
DETAILS OF BANDSAW.
5 H.P. MOTOR AT 2,870 R.P.M.
SAW SPEED 8,000 FT/MIN.
DIRECTION OF FEED.
TEMPLATE AT BOTH ENDS TO GIVE SHAPE REQUIRED.
BLOCK OF EXPANDED HONEYCOMB MATERIAL SHOWING PARALLEL AEROFOIL SHAPE TO BE CUT

BANDSAW FOR CUTTING PARALLEL AEROFOIL SHAPES OF HONEYCOMB SECTION.

FIG. 20.

in the past few months. Some of the machines and ideas described are simple, but I feel can make quite a contribution in reducing production times. Because the machines are simple they are inexpensive, and the machine cost per hour is accordingly low.

Doubts have been expressed about installing big expensive skin mills, which may become obsolete if steel or titanium supersede alloy. Inexpensive routing machines can be made to pay for themselves in a short time, possibly in the forseeable future, so that no risk is taken on this issue. One firm has estimated that a heavy radial router will pay for itself within a year of installation, against existing costs, on their work.

Progress will be made in machine designs by adding complication, but this is best done on a sound basis of machining technique which we are now seeking to establish on these simple machines. The adding of complication will substantially increase the cost, and the question is posed, is there a need for a range of simple machines for airframe machining, or is the ideal " press the button " on a very expensive and complicated machine? This is, of course, an oversimplification of the problem and it is difficult to decide where simplicity finishes and complication begins.

When we come to talk of electronic control and computers, a vastly different issue then arises, because we get solid and substantial advantages for the great complication. The elimination of solid formers with all that that involves is a worthwhile contribution to easing the burden of tooling up for the quantities the aircraft production engineer can expect in this country, and the resultant speed up between the design and production stages, which one hopes would result, would be worth a great deal against the big initial cost.

I hope that in this great step forward to electronic control the British machine tool industry will play its part and give the aircraft industry the equipment it needs to produce its products.

Acknowledgments

I am indebted to Mr. Woodley and Mr. Burnard of Messrs. Vickers-Armstrongs, Ltd., Supermarine Division, South Marston, for photographs of the radial router and skin mill, and to Mr. Teale of Messrs. Short and Harland, Belfast, for the sketch of the horizontal band saw.

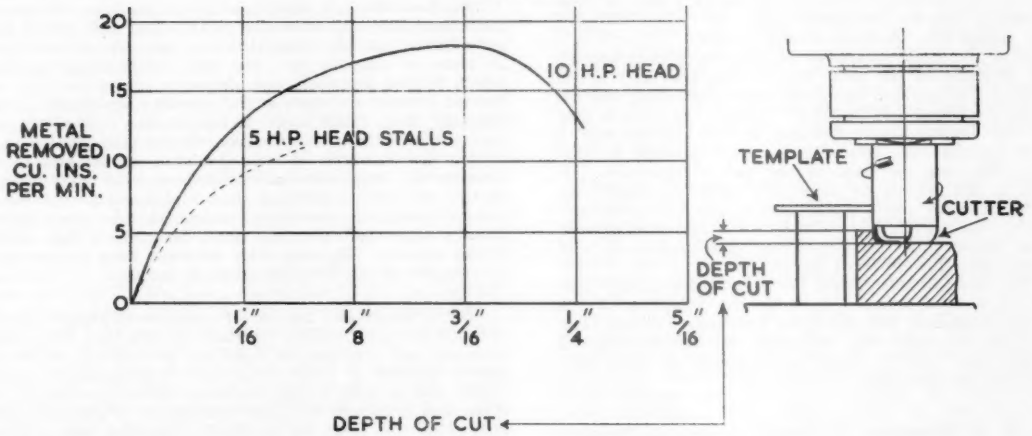
MATERIAL—'NORAL' B.26S—B.S.S. L. 70
CUTTER—2½" Dia. T.C.T. POCKETING CUTTER
AREA OF POCKET 60 SQ. INS.

POCKETING
LYR WITH 10 H.P. HEAD

Cut	Speed	Metal Removed Cu. Ins./ Min.	Tooth Loading	H.P.	Feed Speed Ins./Min.	Metal Removed Cu. Ins. Per Min. Per H.P.	
2½" Dia. × ¼"	12,000	14·5	·0029"	10·3	70	1·4	Pocket 2" Deep (16 Cuts)
2½" Dia. × ¼"	12,000	17·3	·0035"	11	83	1·57	Average Setting Time between Cuts—10 Secs.
2½" Dia. × ¼"	12,000	17·3	·0035"	11·6	83	1·5	Average Time for ¼" Cut—27 Secs.
							Actual Cutting Time—7·2 Mins.
							Total Machining Time—9·87 Mins.
							Total Metal Removed—120 Cu. Ins.
							Metal Removed Average—16·7 Cu. Ins./Min.
2½" Dia. × 1/16"	12,000	18·7	·0025"	14·5	60	1·3	Pocket 2 1/16" Deep (11 Cuts)
2½" Dia. × 1/16"	12,000	19·9	·0027"	15·5	64	1·28	Average Setting Time between Cuts—13 Secs.
2½" Dia. × 1/16"	12,000	16	·0021"	12·9	51½	1·24	Average Time for 1/16" Cut—37 Secs.
							Actual Cutting Time—6·8 Mins.
							Total Machining Time—9·17 Mins.
							Total Metal Removed—124 Cu. Ins.
							Metal Removed Average—13·2 Cu. Ins./Min.
2½" Dia. × 1/16"	12,000	15	·006"	10·3	144	1·45	Pocket 2" Deep (32 Cuts).
2½" Dia. × 1/16"	12,000	15	·006"	9·7	144	1·55	Average Setting Time between Cuts—6 Secs.
2½" Dia. × 1/16"	12,000	13·2	·0053"	12	127	1·1	Average Time for 1/16" Cut—17 Secs.
2½" Dia. × 1/16"	12,000	13·2	·0053"	11·6	127	1·14	Actual Cutting Time—9·07 Mins.
2½" Dia. × 1/16"	12,000	12·5	·005"	12·9	120	·97	Total Machining Time—12·27 Mins.
2½" Dia. × 1/16"	12,000	13·2	·0053"	11·2	127	1·18	Total Metal Removed—120 Cu. Ins.
2½" Dia. × 1/16"	12,000	15	·006"	12·9	144	1·16	Metal Removed Average—13·2 Cu. Ins./Min.
2½" Dia. × 1/16"	12,000	13·2	·0053"	12·9	127	1·02	
2½" Dia. × ¼"	12,000	12·9	·0013"	11·3	31•	1·14	Feed Speed too slow due to depth of Cut.

2½" DIA. POCKET MILL.

(see page 210)



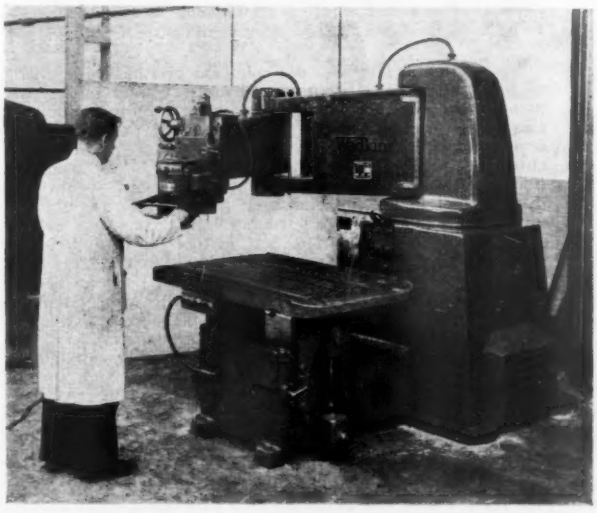


Fig. 6 (A)

(see page 211)

DISCUSSION—SESSION III

Chairman: Mr. F. C. COOKE, M.I.Prod.E.,
General Production Manager, Field Aircraft Services, Ltd.

Mr. S. Radcliffe, before presenting the Paper, explained that it had been written at very short notice, and he had not had the opportunity of going round the machine tool industry in the way he would have wished to gather information to make the Paper more comprehensive. For that reason it had been written principally from his own experience.

After reading page 211 down to the heading "Cutter Design," he added:

"Since this was written the articulated arm routing machine has been assembled and trials were made with it on Wednesday last. On the initial plotting over the area of the table, which is 3' 6"×2' 6", a reading was obtained on the end of the spindle within 0.001" all over, which represents a very much increased accuracy over the arm radial which we have used hitherto. As a further test we did some freehand cutting, and I have a sample here. The surface represents a considerable improvement, working on the bottom of the cutter, over anything that we have done before, and was obtained with a 2½" cutter at 5,000 r.p.m., taking five freehand sweeps across.

"One of the disadvantages of the machine is that, because of the shortness of the outer radial arm, the head moves away from the operator and gives a poor operating position over the far corner of the table. To get over this a long radial arm control has been fitted, so that the operator is able to exercise full control even when working in that corner. We were surprised by the ease of operation. It is obvious that within the next few weeks we shall have to decide whether that type of arm or the one previously illustrated will prove more useful to the industry in general, and the answer may be a judicious combination of both machines, used for different duties."

At the end of the Paper, Mr. Radcliffe added that everything he had referred to, with the exception of the spar milling machine, was purely for light alloy cutting. The spar milling machine was expensive and intended for a specialised job, and it should be arranged to deal with steel as well as light alloy.

Mr. H. A. Chambers, M.I.Prod.E., *(General Manager, Rockwell Machine Tool Co. Ltd.)* said he was sure that everyone present would wish to join him in thanking Mr. Radcliffe for an admirable Paper. It demonstrated the great need for the type of plant described, and Mr. Radcliffe had done a great deal to help production engineers to solve their problems, particularly on the smaller millers. His Company had led in this field for a large number of years and had helped a great deal on many occasions. He had talked about skin milling, and his contribution on that subject had been most interesting. His milling machine would be widely welcomed. The subject had given rise to a great deal of discussion at the Conference.

Mr. Radcliffe had said—and this must be one of the reasons why he had not gone a great deal further in this respect—that the need for cheapness and the question of repeat orders had prevented him from going ahead with the bigger and more complicated machines which they all knew were essential for the machining of integral skins. Mr. Chambers had some information on what was being done in this respect on the other side of the Atlantic, where great strides had been made, but at relatively high cost. At the present time he was told that they could machine a large wing skin, about 25 ft. × 5 ft., in something like 25 to 30 hours, and that should be borne in mind when discussing the subject that morning.

The industry in America got together at a very early stage, with the support of their Government, and decided on a type of machine to deal with their particular problem, and they then went ahead without any hesitation and spent fairly large sums of money in developing the machine which they thought was necessary. They built, he believed, some twelve or fourteen machines, each machine showing a tremendous development over the previous one. He understood that they had now developed a machine with magnetic tape control which had further reduced the time which he had mentioned.

He made those points because he felt that in that country there was six or seven years of development and experience which this country could not afford to ignore, and he would like to hear opinions in the discussion on the subject.

Mr. Radcliffe said that his firm had been out of the alloy field completely for seven or eight years, and it had been only in the last year that they had come back to thinking in terms of alloy at all. He had said that the machines which he had described were simple in conception, but they formed a basis, and even at the present stage in the aircraft industry they could make a contribution. He was well aware of the advances in some of the skin millers made in America, but none of those machines was working in this country, and they were concerned about what could be done at this moment to produce something quickly to help the industry as far as possible. No doubt in the next eighteen months more rapid progress would be made in skin milling in this country. The American machines were far and away in advance of anything being made here.

Mr. C. Bromage *(Assistant Production Manager, Gloster Aircraft Co. Ltd.)* asked whether the machine tool manufacturers had anything in mind for getting rid of the excessive amount of swarf from these high-powered cutters. There was, he said, a large build-up behind the cutter, and there was a danger of chips getting on to the cam bars, and, with the heads hydraulically operated, any chip on the cam bar was automatically reproduced on the component. The extraction of swarf on these machines seemed to be a big problem for the aircraft industry to-day.

Mr. Radcliffe said that the comment presumably applied to spar millers with pneumatic heads. He had raised the point in the Paper of whether they were to go in for down-cutting as standard on their spar millers. If that was to be done, there was something to be said for putting the cutting element at the extreme left-hand end of the machine (looked at from the front), so that the swarf would be thrown clear of the machine itself and the chips would be spilled out at the extreme left-hand end, clear of the headstock of the machine. The best method of dealing with the problem of exhausting chips on the spar miller was the provision of a properly designed exhaust hood for every set-up, but he did not know of anyone who would change the hood every time the cutters were changed, and it was expensive to have complete sets of exhaust hoods.

They were pushing up the exhaust speed to about 8,000 ft./min., and that would help, because with a high speed it should be relatively easy to throw the chips off. At the moment the chips were thrown into the following spindles and it was difficult to get them out, but by putting the cutters at the other end of the headstock and throwing the

chips clear at the back of the headstock an improvement could be made. On the other hand, that might mean, as was said in the Paper, putting the vertical spindle in advance of the horizontal spindle, which might be a disadvantage for some jobs. He would welcome comment on whether that was a disadvantage.

Mr. Bromage said that at the Gloster Aircraft works they used the down-cutting method for speed and safety, and if anything went wrong with the clamping it eliminated the danger of the job shooting out forward of the machine.

Mr. Radcliffe suggested that a great deal could be done with pneumatic exhausting. Even with poor pneumatic exhausting it was possible to take off 90-95% of the chips, but the remaining 5-10% could be an embarrassment.

A Visitor *(English Electric Co. Ltd.)* said that the Paper was the most encouraging which had so far been presented. Instead of tackling the problem of the fully contoured skin Messrs. Wadkin had dealt with the intermediate problem of the flat skin and the type of machine illustrated in Figs. 5 to 12 of the Paper. This drew attention to something on which he would welcome comments from the light alloy manufacturers and from Mr. Radcliffe. He felt that the outstanding missing link at the moment was the production of stress-free stock, stretched stock. If the 5- or 6-ton cast billet to which Mr. Richards had referred could be produced and rolled into some size which would give the size of stock required, the missing link was some means of stretching it. If Messrs. Wadkin could produce the type of machine which had been described, somebody ought to be able to produce a stretcher for that material. He would like the light alloy manufacturers to comment on that proposition.

Mr. Menelaus, *(Tool Development Engineer, Short Bros. & Harland Ltd.)* said that Mr. Radcliffe had covered, the application of machining to light alloys fairly thoroughly, but in other spheres the application of cutters and machines to steel lagged behind. In the Paper by Messrs. Keen and Menzies in the second Session, a process sheet was shown relating to machining up a high-speed component where carbide had been used and high-speed steel, and the speed rates quoted were in the region of 6 in./min. and $\frac{3}{8}$ in. feed for high-speed steel. The difference was in the region of 1,100%. Mr. Keen stated that he had to dispense with climb milling, which was one of the main techniques which should be employed in machining steels, and also light alloys, to get the required finish.

Then, again, most machine tools used in industry today were so light that the specialised cutters which were being developed by the small tool manufacturers today could not be used. They wanted to use helical carbide cutters and face millers but could not put them on because there was not the horse-power available. Most of these small tools did not carry an ammeter, and if one did manage to put a facing cutter on and get 10 - 12 in./min., the operator did not know what power was being employed for that particular cut. He would ask the machine tool manufacturers to take into account the ultra-high-strength steels now coming into use in industry.

Mr. Radcliffe, in fairness to the general run of machine tool manufacturers who catered for iron and steel, said that something quite new and good would probably be seen at the 1956 Exhibition. The general run of machine tool manufacturers had been very busy on exports. That might have created difficulties at home, but at the next Machine Tool Exhibition in 1956, machines would be shown which more nearly met the requirements referred to that morning.

Mr. D. Frankland, *(Chief Process Planner, Westland Aircraft Ltd.)* suggested that in the case of the skin milling machine illustrated in Fig. 11 of the Paper, the operator must be subject to considerable fatigue. When in his seat he passed over the top of the work piece and had to view the cutter below the level of his feet. This meant that he had to hunch forward with arms extended in front controlling the machine travel and with his gaze fixed on a spot approximately 6 in. below his feet. Had Mr. Radcliffe investigated the possibility of a periscope attachment or some other form of optical projection, which would allow the operator to sit comfortably in his seat with a forward view?

Mr. Radcliffe replied that they had not so far done anything in the direction indicated. The machine in question had been working only for five or six months, and their first concern had been to see whether they could produce the skin on the router and whether they could go on producing it with this type of light machine equipment. Now they had proved that it could be done he thought that Mr. Frankland's suggestion, of doing something to improve the operator's position, was very well worth considering, but their first concern had been to establish a technique and see that it would work. It was easy to do a job in one's own shop as a one-off job and get away with it, but to do two skins a day for six months was a different matter. They had now come to the end of the first six months and were still producing satisfactory skins, so that the question arose of what improvements could be made.

The men who operated this machine said that they were quite comfortable, but he agreed that something should be done, and he appreciated the suggestion of using an optical method to give a close view and improve the working position.

The next thing that they had to do was to see whether there would be a demand for this type of machine, or whether the aircraft industry would laugh at it. It would not worry him if they laughed at it, because Messrs. Wadkin were only trying to help the industry. Their policy had been to allocate a proportion of their space to the needs of the aircraft industry, and they were turning woodworking business away to help the aircraft industry, because they felt it was very desirable that the machine tool industry should help and support the airframe builders as much as possible.

Mr. A. Vines, A.M.I.Prod.E., *(Production Manager, Fairey Aviation Co. Ltd.)* commenting on Mr. Radcliffe's remark that his firm had been interested in this problem for the last twelve months, said he thought this was a turning point, as the aircraft industry had been helping themselves since the War when nobody else was interested in their problems.

This, however, was the second part of the problem; the first part which had not yet been faced was to produce satisfactory material. At least ten speakers had said this, and if the Conference achieved the object of getting this whole project on its feet it would be a matter for congratulation. If it were possible to look forward to good material of the right size and stretched, the corner would be turned and integral construction would be a practical possibility in this country.

Mr. Radcliffe remarked that he would welcome criticism from anyone in the industry of anything that had been said, and not just that morning. They were trying to make something of use to the aircraft industry. He was not putting forward anything as being perfect, and if it was felt that some alteration or modification was desirable they would welcome constructive criticism at any time. Anything that could be done to help the industry they would be very glad to do.

Mr. E. J. Frost, A.M.I.Mech.E., Grad.I.E.E., *(Production Manager, Westland Aircraft Ltd.)* said that Mr. Radcliffe had not referred to what was in Mr. Frost's view one of the most useful of the woodworking machines which had been converted to metal working, namely, the spindle moulder. There was a very distinct field for a strengthened spindle moulder, larger than the one which existed at present.

Allied to the problem of cutting with bigger cutters and at higher speeds was the question of safety. There was the question of dynamic balancing, which would ensure that

there was no danger to the operator if the cutter should burst. In addition to that, the quantity of swarf which was produced by these machines constituted a danger to the operator. Had Mr. Radcliffe thought of that as well?

Mr. Radcliffe said that Westland Aircraft made aeroplanes on spindle moulders. He had concentrated that morning on relatively new machines and had taken it that spindling was an old conception well accepted in this country since about 1938.

On the question of dynamic balancing, in the woodworking trade they assumed that if anything had to be done in the way of balancing the machine must be badly designed, because they designed machines to take a certain amount of out-of-balance without any trouble. In the woodworking trade, where a job was done for tuppence-ha'penny, there was no time for over-balancing, and if one mentioned it to some of them they would not know what one was talking about. He had just redesigned a spindle moulder with the object of running out-of-balance without detriment at 4,500 r.p.m. If the cutters were reasonably made, dynamic balancing was not needed.

They had not, since the War, given any attention to the question of swarf. After what had been said that morning, however, they would have to give the question of swarf more consideration. He was sure that more could be done. It would cost money and meant the incorporation of refinements, but if the industry wanted to get rid of its swarf in an economic way it could be done, if the capital was forthcoming to pay for the equipment when it was made.

He would welcome any general remarks or criticism on the spar mill or the 16 ft. × 5 ft. machine. If a firm came to them with a proposition which looked as though it might be a general problem they would like to have a go at it, and any criticism would be most useful if it helped to make the machines more adaptable and useful for other jobs.

Mr. P. V. Brown, A.F.R.Ae.S., A.M.I.Prod.E., (*Directorate of Aircraft Production Development, Ministry of Supply*), referring to the Type W.T. high speed universal milling machine shown in Fig. 13 of the Paper, asked whether Mr. Radcliffe had thought of providing a canting head with hydraulic control, so that fuselage frames and ribs could be made with varying angles. He would have thought that that was an important requirement from the airframe point of view, to be able to put a varying angle on the profile of components.

Mr. Radcliffe replied that the machine was being built with three prototypes, of which the first was being built at the present time and would be finished by the end of March. They had an exercise to do on that, set by Short Bros., who had given them the maximum cant that they wanted, up and down, and they were preparing a special rocking head to attach to the end of the spindle. They had been given the sizes required, and they were designing a special rocking head to try on the machine when completed. He recognised that the job in question was an important one which could be done on a machine of this type, probably for a relatively small cost. At above 6,000 r.p.m. the thrust for holding up the template came down rapidly compared with a low cutter speed and it was easy to float a light spindle and hold it up with low pressures if the cutter speed could be kept up. Now that the spiral carbides were becoming more freely available it was possible to run at 6,000 to 9,000 r.p.m., and it could be held in quite a light saddle or yoke with quite a low thrust compared with the general run of rollers used hitherto on cutters running at, say, 1,000 r.p.m.

Mr. W. J. Morgan, M.B.E., (*General Manager, Machine Tool Trades Association*) said that he hesitated to speak in the presence of so many distinguished aeronautical engineers, because his grey hairs and his tie showed that he belonged to the wood, canvas and dope period. He could not let the opportunity pass, however, without thanking Mr. Radcliffe for the noble way in which, though a very busy man, he had stepped in to rescue him from a difficulty in which he found himself when approached to see whether a Paper could be given from the machine tool angle.

He was very gratified that Mr. Radcliffe had shown that progress was being made. The machine tool industry had been handicapped in the past not only by their export commitments and labour scarcity, but by cramping regulations which had only recently been lifted, and which had made it difficult for firms to expand beyond their current commitments.

The International Machine Tool Exhibition to which Mr. Radcliffe had referred was to be held in June, 1956 at Olympia, when there would be much to be seen representing other phases of progress.

Referring to the skin miller described in the Paper, he would like to know whether there was any possibility of some link between what Mr. Radcliffe was doing and what the Conference had been shown the previous day in line drawing form, a machine working on tapered camber from a virtual centre. Could there be some link between Mr. Radcliffe's skin miller and what had been forecast there?

Mr. Radcliffe said that everything he had shown that morning, with the exception of the W.T., was on the assumption of working on the flat. After listening carefully to the discussion the previous day, he had formed the impression that everybody was not in favour of doing everything in the third dimension and that a great deal more work would be done in two dimensions, with the idea of forming the skin after it had been cut. So far as cutting was concerned, the speaker judged they were in an *impasse*, and that could be broken by the provision of equipment at a reasonable price for further experimental skin milling. He estimated that the skin mill which he had illustrated was worth about £10,000, and that should enable some progress to be made. If some of these skins were produced in quantity, the industry would soon decide whether it was practical to do them in the flat. The discussion the previous day had been based on a relatively limited practical experience of handling these big thick sheets and machining them. If it were possible to produce a few simple machines for two-dimensional work, the industry would soon decide whether to use them and form afterwards or whether it was essential to work in three dimensions in the cutting, and that question would settle itself once these machines were available and firms had gained some practical experience in working with them.

The Conference then adjourned from 11.30 *a.m. to noon.*

WHERE DO WE GO FROM HERE?

by W. E. W. PETTER,
C.B.E., B.A., F.R.Ae.S.

Mr. Petter

Mr. Petter, Managing Director and Chief Engineer of Folland Aircraft, Ltd., was educated at Marlborough and Caius College, Cambridge, afterwards serving an apprenticeship with the Westland Aircraft Works from 1929 to 1931. He became Technical Director of this company in 1935 and before joining the English Electric Company as Chief Engineer of the Aviation Division, in 1944, had become known as the designer of the Lysander army co-operation monoplane, the Whirlwind fighter bomber and the Welkin high altitude interceptor fighter.

While with the English Electric Company, he added to his earlier reputation by designing the Canberra.

Mr. Petter began to study the problems of the light fighter in 1951, soon after joining Folland Aircraft, Ltd., where he designed the Midge and the Gnat. He is now probably the greatest authority on the subject in this country.

WHEN I was asked to wind up the Proceedings of this Conference, I was given a wonderful title : " Where do we go from here?" The Southern Section Committee were so good as to say that I could choose my own approach and, since I do not feel qualified to sum up all that has been said, I do not intend to try, and I know that the speakers will forgive me. I propose to refer to only a few of the points which have come up, and which struck me very much, before going on to my own remarks.

Mr. Woodward-Nutt brought a very important matter to our attention when he spoke of the smaller numbers of aircraft for which orders might be placed in future. That is going to mean a somewhat different approach for all of us.

Another point which struck me, and of which I do not think that enough has been made, is that integral construction falls into two parts. There is the wing skin milling, which has been discussed at some length, but that is by no means the sole or possibly even the most important problem in integral construction. The machining of large slabs into fittings and forgings, or the production of forgings from stock, will become more and more important as the numbers increase and forgings are less easily available. In that respect Mr. Radcliffe's Paper draws attention to a most important new approach, the routing approach. When you are cleaning up forgings you do not want to get ± 0.002 in. You are quite satisfied with $+0.010$ and -0. I think myself that the woodworking approach is the right one and the diesinking approach may well be the wrong one. We should not be depressed if our methods are not as advanced as those of the Americans, because it may be that the sledgehammer is not the right way to crack a nut. There is one way in which skin milling may be eliminated, and that is to make the wings of such small span that it is not necessary!

The Real Problem

One might think that our main problem was to apply our production knowledge. What we know is that in the most advanced fields of aviation generally and in this country in particular, the real problem is to keep production turning at all and to produce things which can be used when they leave the hangar doors. The real and the biggest problem in British aviation today is—so it seems to me—to find how to canalise the work of our limited research, designing and development manpower through the right channels in order that we may have a certain number of producible aeroplanes, in the various

classes, which meet our essential needs at the right time. It is this problem, which must be solved if we are to go anywhere from here, with which I will try to deal briefly today.

Our air effort as at present constituted rests upon three supports: the customer who must frame the requirements, an industry which must fulfil them, and a Supply organisation which must co-ordinate the two. Any lack of effectiveness in any of the three essential legs of the tripod on which we build will immediately show itself in the outcome of our efforts. It is because there have been weaknesses in each that our air situation is far from satisfactory today. I shall try to indicate what, in my opinion, are these weaknesses and to suggest how some of them might be eliminated.

Customer Requirements

Everything starts with the customer requirements, so we will consider these first.

The framing of requirements, especially in the military field, is a duty of appalling responsibility. If over-ambitious, the problems set to the designer will be of such complexity that he will either not achieve production at all or be so late as to be obsolete. If too easy, we might be faced one day with an enemy, or competitor, possessing technical superiority.

The specification writers since the War have, in my opinion, tended to set their sights much too high; they have aimed too far ahead—and no doubt the industry (in which I include the equipment and armament manufacturers who, together with the engine and airframe people, make up the weapon system) must take a grave responsibility for being too ready in their promises—perhaps I should say our promises. We have, for instance, underestimated the difficulties of supersonic flight, the time scale of new radar sets, the time to develop new weapons. A somewhat doubtful time scale has perhaps seemed unimportant in a political background which seems always to have put any war possibility a comfortable four to five years ahead!

As Ed. Heinemann, Chief Engineer of El Segundo, (who has made a great contribution to the simplification and lightening of high performance aircraft) so truly said recently in a Paper presented to the Society of Automotive Engineers: "A specification must consider not only what is possible, desirable and necessary, but also what is practical either now or in the near future". And again, *apropos* the appalling increase of size, complexity and weight which is occurring on both sides of the Atlantic, but which we can afford much less than the U.S.A., he said: "The importance of weight can be expressed in a few words—excess weight is accompanied by inferior performance, disproportionately higher cost and decreased reliability". I do not in the military field yet detect any significant signs of a return to realism in this country.

Dangers of Over-commitment

On the industrial side our gravest fault has been, I think, overcommitment—too many channels for too little water. Designing and developing an aeroplane today is a tremendous undertaking and it needs the almost undivided attention of whoever in the firm is the Chief Design Executive, together with all his staff, for a period of five to six years—three, perhaps, for the project work and the design and building of the prototypes, and three thereafter to make them work in association with the customer, and to incorporate such modifications as are needed for production. The number of men who combine the qualities of leadership, inventiveness and diplomacy with those of character necessary for the top design job certainly appear to be no more than the number of approved aircraft firms today; apart from the leaders there are hardly sufficient sound lieutenants, the people who really do much of the work, to go round even the good existing teams, and the same is found even more acutely at the level of designers and technicians.

If you accept my 'six-year' hypothesis, one only has to do a little arithmetic to see how few good new aeroplanes Britain can really produce in say ten years, and this has to cover the full range of bomber, fighter, large and small civil aircraft, helicopters, naval machines of various types. The facts would seem to confirm the arithmetic. Yet to take only one example—we see about twice as many machines in the largest class, military and civil, being attempted as I would judge the country can manage if it is to get its aircraft in the right time, adequately developed, while leaving sufficient manpower over for other essential types. We have many examples in aeronautical history where even the strongest firms have fallen short technically or in time, by trying to follow one big success with another immediate major effort—but it unfortunately takes an unusually strong-minded firm and designer to decline an interesting new prototype order. So that the cure for this particular ill must be sought mainly in official quarters. Technical over-commitment is one of the scourges of our profession.

To the question recently so pertinently raised by your President—"whether . . . we can afford to make a very little of everything which is all that present costs and budgets allow . . .", I for one would return an emphatic: "We can't".

Designers' 'Dance of Death'

In this matter you production people can help considerably, and I don't mean only directly. There is a tendency for factory management to seek expansion at all costs and so to demand an ever-increasing flow of prototypes that with due allowances for failure there shall always be assumed large production work. This is the dance of death for the designers. Less new endeavours, fully and lovingly completed, would certainly ensure more, not fewer production successes.

The wider use of sub-contracting within the industry, as suggested by Professor Richards, is one answer to the production problem; another is that the production people themselves should be encouraged to help more in the development stages, and it is

astonishing how much help a willing aircraft production team can give. If we were less overcommitted, more would be foreseen and there would be less modification, but nevertheless a far more sympathetic attitude to important modifications by most production people would be of inestimable help not only to the designers, but to the country.

Indeed, I would say that it would be better to forget all about new techniques such as skin-milling until we have caught up with and passed the lamentable state of affairs which is sometimes heard of when machines, urgently needed, go straight from the factory, not to the Services, but for weeks or months to Service modification units.

A new major aircraft only every six years is not, perhaps, calculated altogether to satisfy the younger technical and project designers. The solution is probably to sandwich in research design and flight work, of which a vast amount needs to be done and for which contracts can usually be obtained, choosing a subject which accords with the firm's interests and future aspirations.

Unbalanced Organisation

Another weakness in the industrial leg of our tripod is due to unbalanced organisation; too much emphasis being often given to the production and commercial side and a quite inadequate weight to engineering. The top engineering executive should be, as he is in America, in name and in fact, at least a Vice-President Engineering. There is still, in some firms, a tendency, out of all keeping with his outside responsibilities and the internal leadership and power of decision which he must exercise, at times even on matters vitally affecting production—to regard the Design Head as a 'back room boy' to be brought out only on gala occasions. In an industry in which engineering touches every aspect of activity, this is plainly disastrous.

Our best firms—and these include those who have delivered most of the goods—are not organised in this way; but some still are, and in these there is inevitably a degree of wasted ability and enthusiasm which we simply cannot afford; while in the nature of things, good work will not come out.

The Vital Element

There is, however, a third and vital element in the aviation scene, if a properly organised industry and a reasonable customer are between them to get the answer; I refer to the Supply and Production Ministry, which correlates the two. This has powers for good or ill which have not always been realised, or well exercised. It should be, and at its best has been, a sound balancing force, watchful to prevent excess and wasted effort between the over-enthusiasm of the Service specification writers, whose assumptions and those of the scientists who advise them, must be independently examined; while also on guard that particular and general commitments in firms and in the country as a whole are such that the best possible use is being made of our manpower and that no more is being attempted than can be brought to fruition in a satisfactory condition and time.

The Supply Department has the power of handing out the rewards and "pains" of good or bad industrial performance, and I believe it will only do good if rewards and pains can be magnified. Just as there have been times when the Supply Ministry has helped to keep going machines that have subsequently proved to be of vital worth, such as the Mosquito and the Viscount, when the would-be user has temporarily lost interest, so there have been times when, since the War, this essential balancing force seem to have become ineffective and I think that many of our present difficulties can be attributed to that.

In peace-time there is a temptation for the Ministries to be increasingly absorbed in the framing and enforcement of requirements. While some requirements are necessary, we designers often cast envious eyes at the army of talent in the Ministries dealing with them; particularly when contemplating our small resources of men with which we must wrestle, not only with Nature, but with the bureaucracy as well. Somehow we ought to secure a double advantage by getting half of them to desert to us!

Policy of Shorter Steps

The true role of the people concerned with aircraft supply, under whatever name they may function, is, of course, much wider than this and there are signs that this is being again realised. I am glad to note, in particular, that a policy of shorter steps now seems to be finding favour. If one is aiming seven years ahead, the problem postulated is such that the chances of success on each of the airframe, weapon and guidance equipment is probably no more than one in two. Taken all together, therefore, there is a one-in-eight chance of success, further reduced by any power plant disappointments. A one-in-eight chance which, in fact, probably takes ten years, is not good enough, but it is no use blaming only the aircraft designers. Now, if a target of only four to five years is taken, the chances on the aircraft, weapon and guidance should be at least three : four each, so that the overall project should have something better than a 27 :64 or, say, 1 :2 chance. What is much more, it is likely to be on or near time; it is less liable to policy changes which might render it useless, and the shorter time scale makes it easier to anticipate any changes or switching which may be required in the event of a partial failure of any of the component parts of our weapon system. At any rate, the chance of success in time—and there is no other success in aviation—is about four times as good in the short step as in the long. In fact, in this way you production people should get something to produce. We must hope that the suppliers will be able to convince the users of the rightness of short steps—indeed, we must help them to do so.

In times of difficulty, it is easy to turn to the short-cut palliatives or curealls, and no doubt we shall be hearing of the advantages of nationalisation or large-scale rationalisation. In my view, neither offers any hope whatever of a solution. Under whatever heads

we have to bring together the elements of a user who must be helped to know what he can reasonably have, and a manufacturer capable of seeing and doing the best possible in the time, including the surveillance of his collaborators in the weapons system. Between these two we cannot dispense with a co-ordinating body and with the balancing factor of the research establishments, speaking through men of sound judgement in some independent organisation as the Supply Ministry.

Independent Administration

For their correct functioning and mutual interaction, these three complementary supports of our air effort must be independent administratively. I can see nothing but ossification arising from the attempt to put the three under one roof, as would occur under nationalisation. It is bad enough now, when like all human institutions, one of the three legs of our organisational stool becomes wobbly — as was seen during the early '30's, when an impoverished industry was increasingly wrapped up in biplanes and red tape by the users — who seemed to have forgotten they might have to fight a war, and the Supply Ministry — who wished to produce aircraft of excessive versatility. An escape was only made to monoplanes and sanity at the beginning of the Rearmament Programme, with some prodding from such brilliant and unconventional efforts as the Hawker Hart and the Vickers Wellesley.

There are, correspondingly, dangers in the too close association of any of the three partners, to the detriment of the third. The solution of industrial rationalisation is superficially more attractive and for big machines requiring large resources of men and research equipment sizable units are undoubtedly necessary. The determining factor, however, should be to seek the best conditions according to aircraft type, under which the most difficult task of creation and development can be fulfilled; and at any rate for the smaller military and civil aircraft I believe that the best results can be obtained from units whose technical and design staffs, excluding the Experimental Shops, probably consist of between 100 and 200 people, since larger numbers than this cannot be beneficially employed on even the complex smaller aircraft. There will be, undoubtedly, a very much greater degree of enthusiasm and energy shown if the team forms part of an independent aircraft organisation and these qualities are also more easily fostered in the medium or small firm than the very large one.

For the design team to be of any use, its firm must be a producer and tooler up of its own aircraft, since a large proportion of the time put into the design has got to be in the creation of light, simple and easily produced detail, and this art will be quickly forgotten by those no longer associated with production.

Personally, therefore, I believe that we should at all costs eschew leaps into reorganisations of whatever political hue, but rather put our faith in the three-legged stool, suitably stiffened up, of the interacting user/manufacturer/Supply Ministry — arranging so far as possible that each is effective and on top of its job, and is imbued with the essential qualities of commonsense, honesty, energy and courage. When we are battling with such odds and all have so much to learn, nothing less will do.

I am aware that some of what I have said may be regarded as controversial, but perhaps this does not come amiss at this time. Further, I am but returning the compliment of your President, who recently lectured very ably to the Royal Aeronautical Society on "Where Goes The Aircraft Industry?" You will see, however, that on one point I disagree with him fundamentally in his view that the biggest problem before us is to get production going. I would rather say that our biggest problem is to provide the conditions in which design and development can prosper.

The Creative Source

It is the small pool of technological manpower, to be found in our drawing and technical offices, our experimental test and flight organisations, and certainly, too, in sections of our Government establishments, which is our creative source. Many years will go by before education and experience will swell the numbers to meet the needs. Meanwhile, production can only start where these people taper off.

Having been outside the full flood of aircraft activities for a few years, and having enjoyed the opportunity of refreshing my production experience, I am perhaps also in a position to see quite a lot of the game as it is played around me. Only it is more than a game, and the vital defence of our country and Commonwealth — and also a very large slice of our export trade — depend on the solution of these problems.

I am, indeed, grateful to your Institution for allowing me to give utterance to my reflections on how we might, perhaps, yet go far from here.

The **Chairman** said that in view of the way in which the audience had received the Paper there was no need for a formal vote of thanks.

It remained for him to wish all those who had attended the Conference a safe journey home, but before they left he was sure that they would wish to pass a vote of thanks to the speakers for giving so much time, energy and thought to their subjects, and to them and all who had co-operated with them for providing some very useful information and making the Conference so successful. Their grateful thanks were due to Mr. Woodward-Nutt, Mr. Richards, Messrs. Keen and Menzies, Mr. Radcliffe and Mr. Petter, and also to the Chairmen of the different Sessions. He was sure it would be desired that he should thank also the Secretary and his staff for the work that they had done, and also the Vice-Chancellor, the Registrar and all the others who had helped in the University of Southampton. Finally, he thanked all those who had joined in the discussions and made the Conference go so well.

The vote of thanks was carried by acclamation, and the Conference was then concluded.

THE INDUSTRIAL USES OF "TERYLENE" POLYESTER FIBRE

by D. N. MARVIN.

Presented to a Regional Meeting of the Institution at Huddersfield, 4th October, 1954.

Mr. Marvin

Mr. Marvin was educated at Ilkestone Grammar School and University College, Nottingham; where he qualified as an Associate of the Royal Institute of Chemistry and an Associate of the Textile Institute.

From 1942/1945 he was employed in the production of explosives at I.C.I., Limited, Nobel Division, from which he joined the Plastics Division. Since that time he has been intimately concerned with the development of "Terylene" polyester fibre, which is now being manufactured by the "Terylene" Council of I.C.I., Limited.

Mr. Marvin is now Assistant Manager of the Technical Service Department of this organisation, and is responsible for technical service and development of "Terylene" polyester filament yarn.

"TERYLENE" polyester fibre is a product of British research, discovered by Whinfield and Dickson in the laboratories of the Calico Printers Association between 1939 and 1941. Later, I.C.I. acquired the world rights to the patents, except for the U.S.A., where a similar fibre is being developed under the name of "Dacron". The fibre is derived from the polymer, polyethylene terephthalate, a condensation product of terephthalic acid and ethylene glycol, which are obtained by chemical synthesis from the products of mineral oil cracking. The fibre, which is melt spun, is manufactured in two forms, filament yarn and staple fibre.

Staple fibre is in the early stages of development, but evaluation of filament yarn over a wide field of applications has been in progress for some considerable time. It is essentially this product with which we shall mostly concern ourselves this evening, since for the majority of industrial applications so far developed, and in particular in mechanical products, the indications are that it is more appropriate than staple fibre because of its higher strength and other physical characteristics.

Properties of "Terylene" Filament Yarn

Currently in manufacture are two types of filament yarn, a medium tenacity, which is more suitable for apparel and household uses, and a high tenacity type of most use for industrial applications.

Physical Properties

The physical properties of the medium and high tenacity yarns are given in Table I.

It will be observed that "Terylene" filament yarns, and in particular the high tenacity type, possess high tensile strength, coupled with a low extension at break and a high initial modulus of stretch. Also the evidence available indicates the abrasion and flex fatigue resistance of "Terylene" to be of high order. The load extension characteristics of "Terylene" are compared with other fibres in Fig. 1, from which the higher initial modulus of stretch of "Terylene" will be observed.

TABLE I

	Medium tenacity	*High tenacity*
Deniers	50, 75, 100 & 150	125 & 250
Tenacity g.p.d.	4.5 - 5.5	6 - 7
Extension at break % ...	25 - 15	12.5 - 7.5
Ratio $\frac{\text{Loop tenacity}}{\text{Tenacity}}$ % ...	About 90	About 80
Ratio $\frac{\text{Knot tenacity}}{\text{Tenacity}}$ % ...	About 70	About 70
Modulus of elasticity g.p.d.	About 100	About 120
Yield point—Stress g.p.d.	About 1.3	About 1.4
Strain % ...	About 1.5	About 0.9

" Terylene " is a hydrophobic fibre and at 65% relative humidity and 25°C absorbs about 0.4% moisture.

Other fibres which are currently in use in industrial applications are in the main high tenacity rayon, cotton, wool and to a lesser extent, nylon, and the essential properties of these fibres are compared with those of " Terylene " in Table II.

Thus, the outstanding characteristics of "Terylene" are very high dry and wet strength, coupled with low extension at break, high initial modulus of stretch and low moisture regain.

In industrial applications it is not only the initial physical properties of the fibre which are of importance, but its ability to retain them when exposed to outside agencies such as heat, sunlight, chemicals, etc. and it is appropriate at this stage to consider the resistance of " Terylene " to the various agencies which are of interest in industrial applications.

Chemical Properties

(a) *Resistance to acids*

" Terylene " possesses an excellent resistance to mineral and organic acids and especially to hydrofluoric acid.

(b) *Resistance to alkalis*

Although a polyester and, therefore, being subject to hydrolysis, " Terylene " has nevertheless adequate resistance to alkali for a textile fibre.

(c) *Resistance to oxidising and reducing agents*

In its resistance to oxidising and reducing agents " Terylene " is outstanding.

(d) *Resistance to organic solvents*

" Terylene " shows no loss of strength after immersion for 24 hours in acetone, chloroform, benzene, trichlorethylene, and carbon tetrachloride. However, at their boiling point, all these solvents, with the exception of carbon tetrachloride, cause " Terylene " yarns and fabrics to shrink unless they have previously been heat set. Heat setting will be discussed in greater detail later in the Paper.

Other Properties

Resistance to Heat

The heat resistance of " Terylene " yarns is out-

TABLE II

	" Terylene " Filament Yarn		Nylon Filament Yarn		Tenasco Tyre Cord Rayon	Glass Fibre	" Terylene " Staple Fibre	Cotton	Wool
	Medium Tenacity	High Tenacity	Medium Tenacity	High Tenacity					
Specific gravity	1.38	1.38	1.14	1.14	1.52	2.56	1.38	1.52	1.32
Tensile strength g/den	4.5–5.5	6–7	4.5–5.5	6–7	3.5	6.3–6.9	3.5–4.0	3.5	1.4
Extension at break	25–15	12.5–7.5	25–20	19–15	10	3–4	40–25	7	38
Ratio $\frac{\text{Wet tensile strength}}{\text{Dry tensile strength}}$	100	100	85–90	85–90	65	81	100	110–130	76–97
Moisture regain %	0.4	0.4	4.2	4.2	13.0	Nil	0.4	8.5	16
Initial modulus of stretch g/den	100	120	24	45	75	307	50–55	55	28

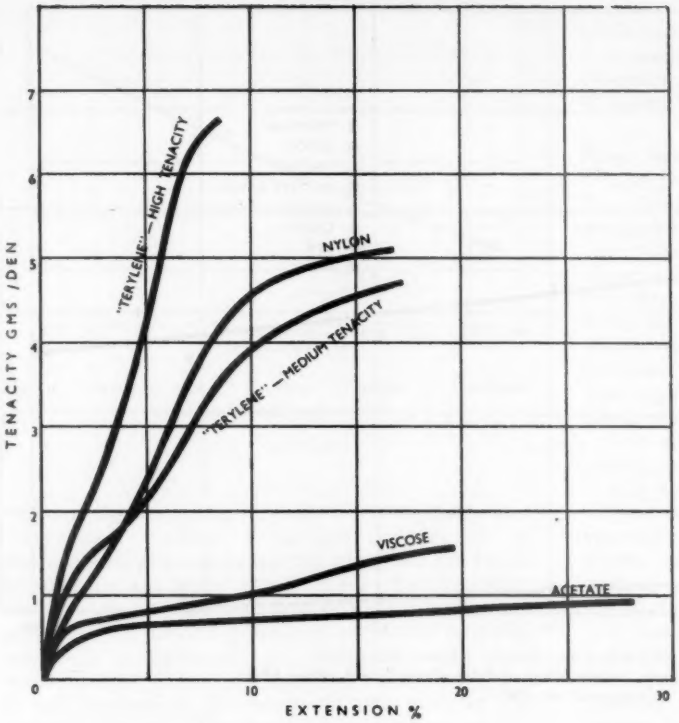


Fig. 1. Load extension curves of some textile fibres.

standing. Thus, on exposing to air at 150°C for 168 hours, they lost only from 15 to 30% of their original strength while after 1,000 hours at the same temperature, the loss was only 50%. The behaviour of "Terylene" and other fibres is indicated in Figs. 2 and 3.

It will be seen that "Terylene" is superior in its heat resistance to all other fibres tested and furthermore, its resistance to change in colour is also superior to that of other fibres.

Tensile Properties at Elevated and Depressed Temperatures

Since "Terylene" is a thermoplastic material, its tensile strength varies inversely, and its extensibility at break directly, with temperature. Fig. 4 indicates the tensile strength of yarn tested at temperatures up to 200°C and at 180°C it still retains approximately half of its original tenacity.

At -40°C, the tenacity of the fibre increases 6%, while its extensibility decreases 30%.

Resistance to Actinic Degradation

As measured by the percentage retention of tensile strength, "Terylene" is approximately equal to the best of the natural fibres in its resistance to the action of full sunlight. Since, weight for weight, it has a substantially higher initial tensile strength than the natural fibres, and, moreover, is much more resistant to the deleterious action of moisture, chemicals, mildew, etc., it may in practice be found that "Terylene" has a longer useful life when exposed to outdoor weathering.

When "Terylene" is, however, exposed behind glass or "Perspex" as, for example, when used as curtains, it will be found to have a considerably longer life than most natural and synthetic fibres. This is due to the fact that the only wavelengths of sunlight harmfully absorbed by "Terylene" are those of about 300 - 300 in the ultra-violet region, which are cut off by glass.

Results of exposure tests to full sunlight (weather exposure) and behind "Perspex" sheet (daylight exposure) on "Terylene" and on other fibres are given in Figs. 5 and 6.

Resistance to Rot

"Terylene" is extremely resistant to rot, marine organisms, mildew, bacteria and insects.

Electrical Properties

"Terylene" is a good insulant and its main advantage in electrical applications is that its electrical and mechanical properties are maintained at temperatures up to 180°C. The absorption of moisture by "Terylene" is, as already stated, small, so that there is little effect on its properties from this cause, an important point in electrical applications.

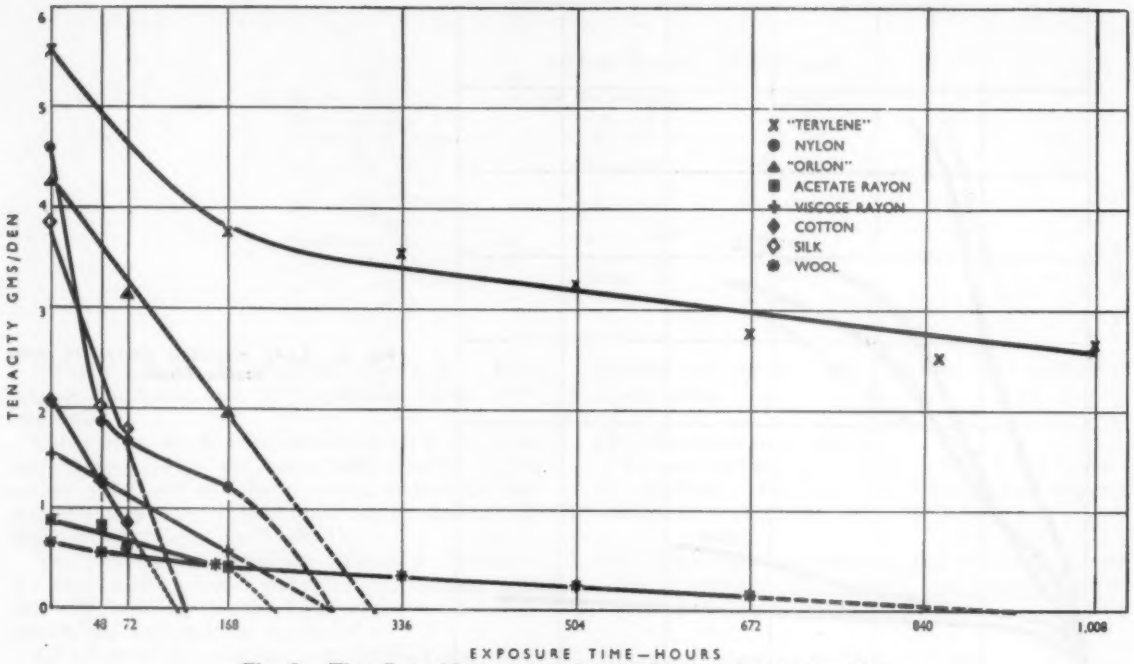


Fig. 2. The effect of heat on tenacity of "Terylene" and other fibres (exposed at 150°C)

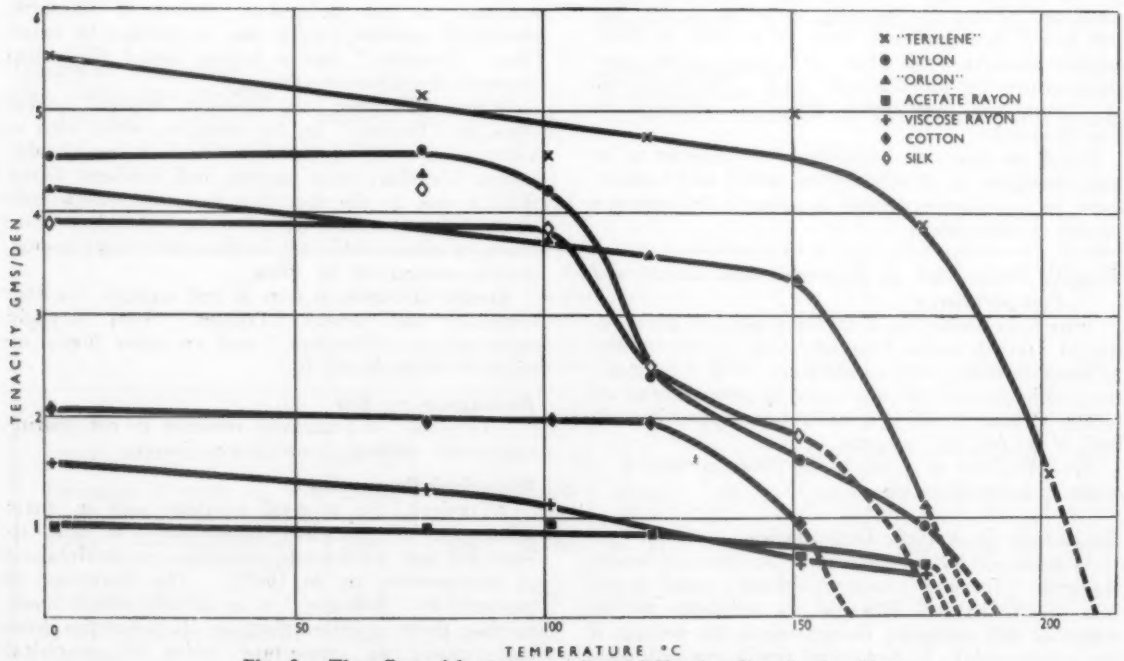


Fig. 3. The effect of heat on tenacity of "Terylene" and other fibres (exposed for 72 hours at various temperatures).

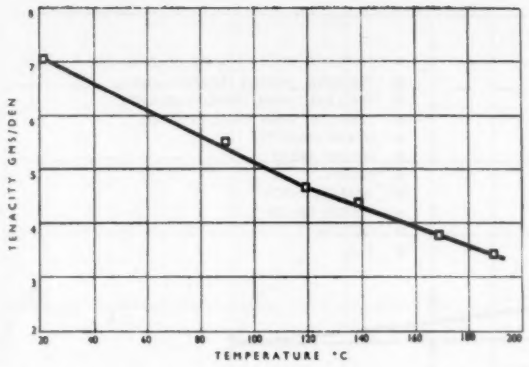


Fig. 4. Tenacity of "Terylene" yarn at elevated temperatures.

From the foregoing it will be recognised that "Terylene" possesses a unique combination of chemical and physical properties which are not found together in any other textile fibre. In particular, the high tenacity filament yarn possesses the essential properties for providing products of greater potential functional performance and technical merit than those currently being manufactured from other fibres. It was because of this potential that, early in the development of "Terylene", a proportion of the limited output of the fibre was set aside to determine how it could best be employed in industry to effect economic savings and increased efficiencies.

Before considering the industrial end use applications which have been or are being developed, it is essential to consider an important stage in the processing of "Terylene", which consists of a process of dimensional stabilisation termed heat setting.

Heat Setting

"Terylene" filament yarn may be converted into the fabrics and cords required for industrial applications by methods similar to those used for other fibres. However, as manufactured, "Terylene" filament yarn, and, therefore, fabrics and corded structures made from it, possess the property of shrinking or retracting when exposed to elevated temperatures; thus "Terylene" yarn in an unrestricted state shrinks by about 7% in boiling water. The higher the temperature to which the yarn or fabric is exposed, the higher the resultant shrinkage, and an approximate linear relationship exists between shrinkage and temperature (Fig. 7).

It is clearly necessary, therefore, that "Terylene" fabrics, cords, or other structures which are to be exposed to elevated temperatures in their subsequent history, either during fabrication of the end product such as a pressure hose or conveyor belt, or during use as the end product, as in a filtration or electrical insulating fabric, must be effectively stabilised in order that (a) shrinkage of the "Terylene" fabric or cord does not occur with consequent loss of those physical properties, namely, high initial modulus of stretch and low extensibility, which makes "Terylene" emminently suitable for mechanical goods applications, and (b) the end product dimensions may be accurately defined. Preshrinking of the fabric or

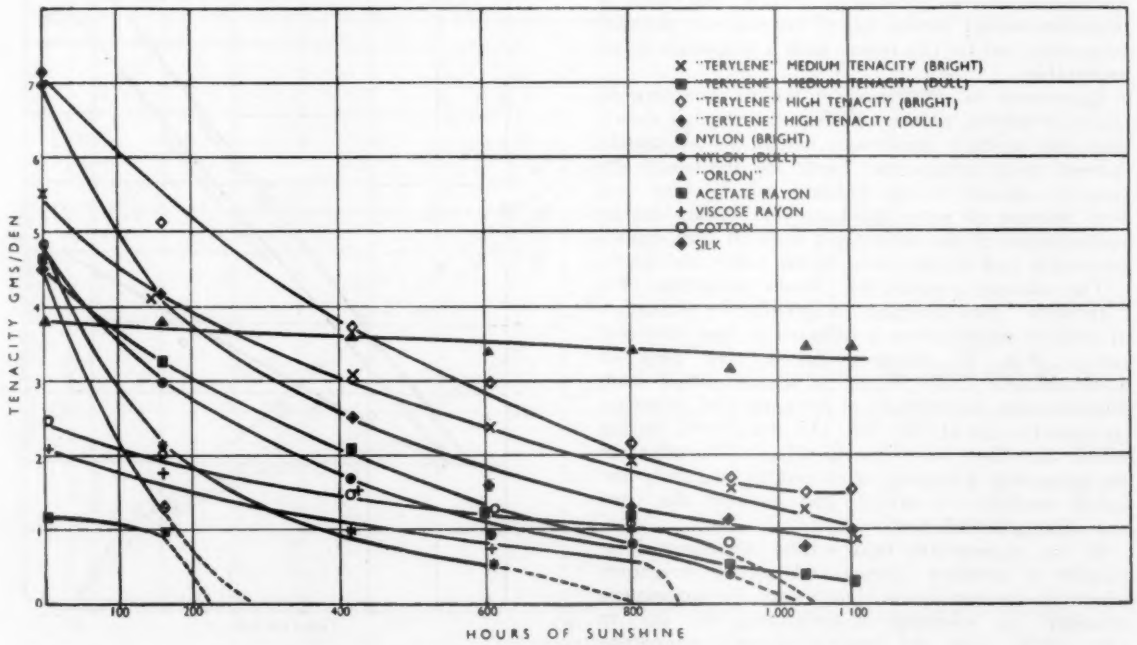


Fig. 5. Weather tendering of "Terylene" and other fibres. (Exposed at Welwyn Garden City, 19th May/1st December 1949).

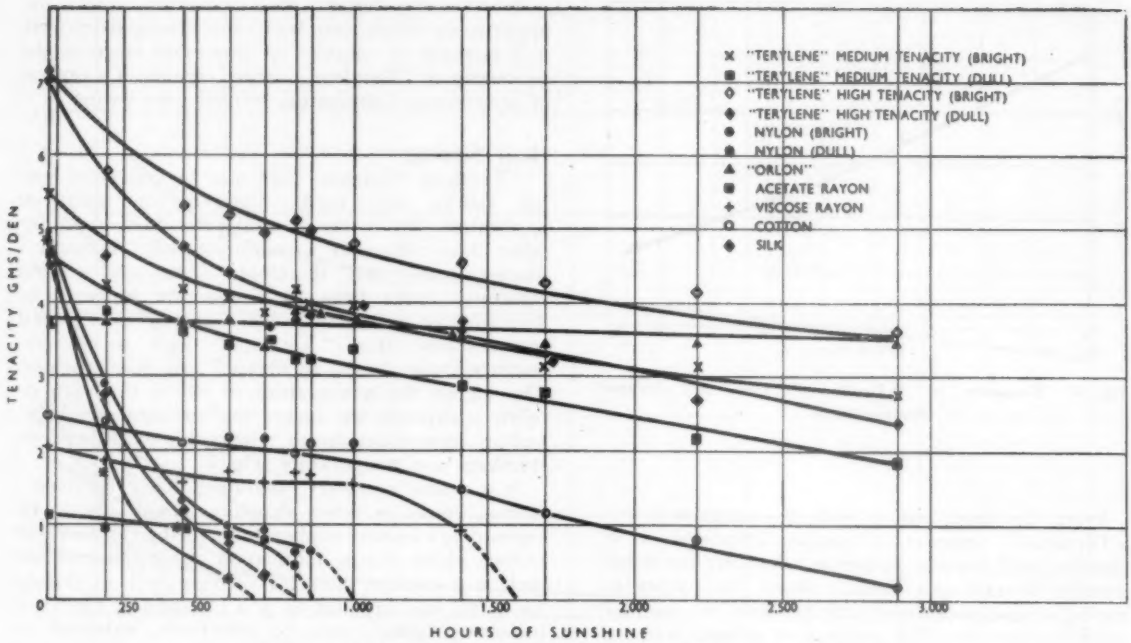


Fig. 6. Light tendering of " Terylene " and other fibres. (Exposed at Welwyn Garden City, 23rd June, 1949/24th May, 1951).

cord prior to use would enable end product dimensions to be accurately defined, but such a procedure would involve loss of the requisite physical properties, and for this reason such a procedure is not acceptable.

Experience in, for example, the manufacture of conveyor belting, pressure hoses and tyres, has shown that end product dimensions cannot be accurately defined using fabrics and cords are frequently incorrectly located in the finished belting, hose and tyre, because of yarn shrinkage that occurs during vulcanisation of the rubber and such, in turn, causes movement and displacement of the fabric and cords.

The manner in which the physical properties of a " Terylene " cord structure are modified by relaxation at elevated temperatures is reflected in load-extension curves (Fig. 8), obtained on a tyre cord of approximately 2,000 denier as manufactured from filament yarn, and samples of the same cord following treatment in air at 125, 150, 175 and 200°C, during which time they were free to relax. The effect of the relaxation treatment is to reduce markedly the initial modulus of stretch and increase the cord extensibility at all loads.

By an appropriate heat setting treatment it is possible to produce fabrics and corded structures which (a) do not shrink significantly on subsequent exposure to elevated temperatures of up to 150 - 180°C, and, (b) possess physical properties which do not differ materially from those of an untreated fabric and cord made from " Terylene "

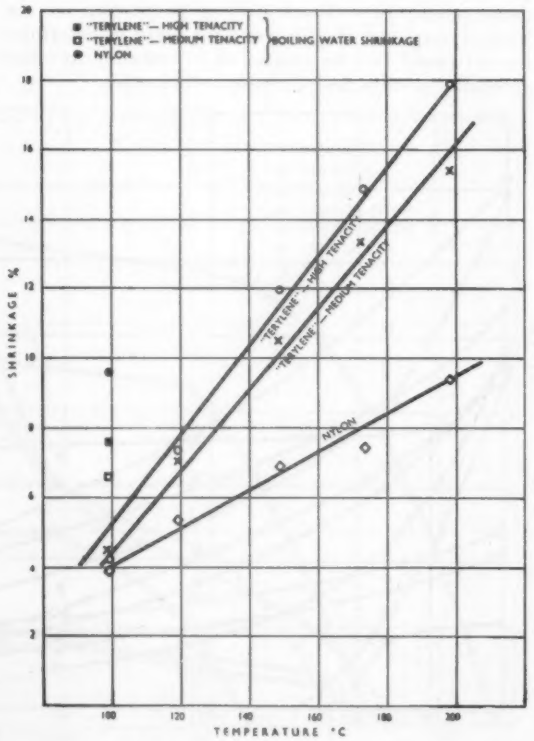


Fig. 7. Shrinkage in hot air of " Terylene " and nylon yarn.

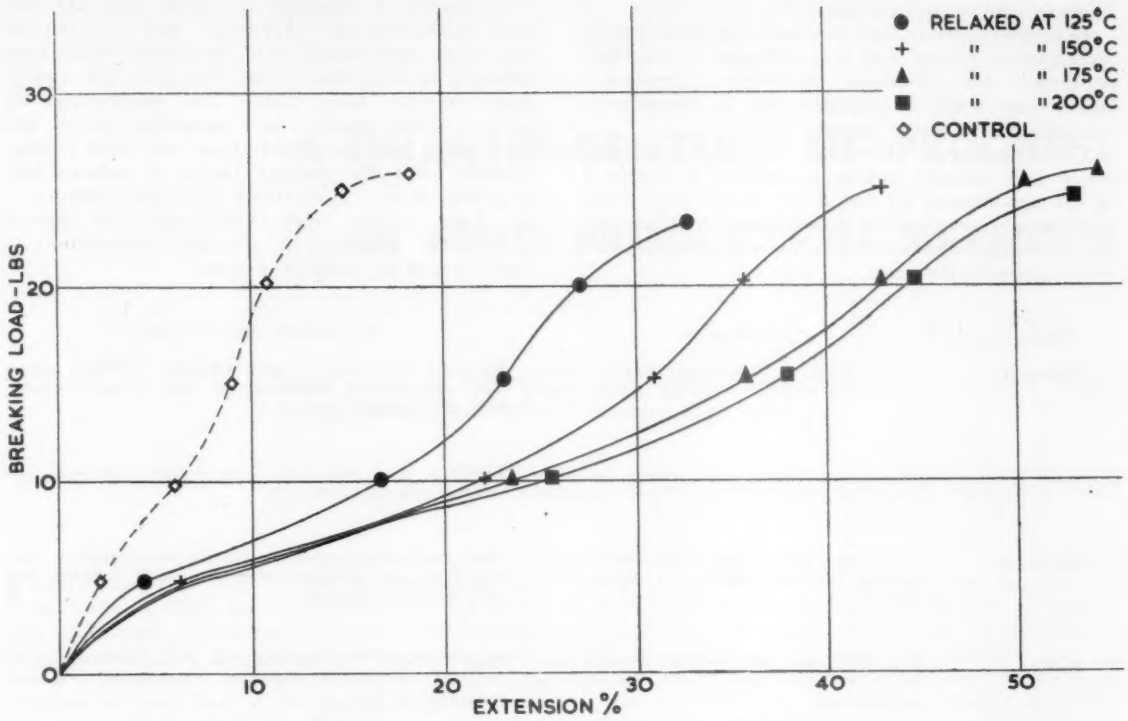


Fig. 8. Load extension curves for "Terylene" filament cord relaxed at 125°, 150°, 175° and 200°C.

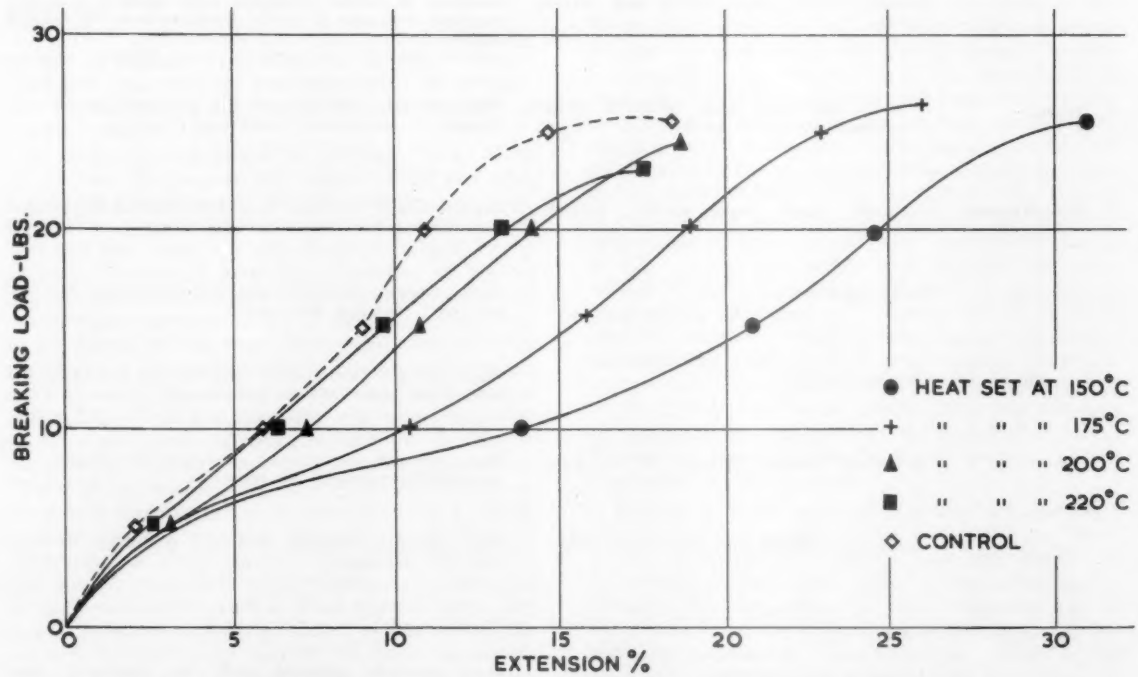


Fig. 9. Load extension curves for "Terylene" filament cord, heat set at 150°, 175°, 200°, 220°C., with 1% stretch and then relaxed at 150°C. for 20 minutes.

filament yarn as manufactured (Fig. 9).

It is inappropriate here to discuss the heat setting techniques employed and it is sufficient to state that equipment for effectively stabilising "Terylene" fabrics and cords is available and in commercial operation in the textile industry.

The versatility of "Terylene" and the contribution which it is already making to industry is reflected in the applications set out below which have been made or are in the course of development. These are for convenience divided into the various industries which consume the fibre.

A number of important industrial uses have now been established for "Terylene" and it is obvious that many more remain to be developed. Apart from effecting an economic saving on a price/life and/or price/strength basis, there are possibilities for revolutionising product and equipment design and facilitating processes which have not been possible hitherto with the existing range of commercially available fibres. Much work, therefore, remains to be done, arising from which one can foresee "Terylene" making an effective contribution to industry and the nation's economy.

Industry	*Applications*	*Contributing Fibre Property*
1 ***Chemical***	Filter cloths, acid resistant braids, safety belts, acid resistant clothing, anode bags.	Excellent resistance to acids, bleaches, oxidising agents and concentrated solutions of salts. High strength, flex and abrasion resistance.
2. ***Steel***	Drop stamp belting, filter cloths for gases.	Excellent heat resistance, high strength, abrasion and flex resistance.
3. ***Electrical***	Insulating sheet, tape and twine, wire lapping, braided covers for flexes, core threads.	High insulation properties coupled with excellent heat resistance, low moisture absorption, high strength, flex and abrasion resistance.
4. ***Rubber***	Tyre cords, vee belts, belting, pressure hose, fire hose, brake hose, fabrics for proofing and coating.	High strength, flex and abrasion resistance, high initial modulus of stretch and low extensibility, excellent resistance to rot.
5. ***Maritime***	Towing strings and hawsers, fishing nets and lines, yachting ropes, sail cloths, whaling ropes, ships' hatch and lifeboat covers.	High dry and wet strength, high abrasion and flex resistance and low moisture absorption, excellent resistance to marine organisms, good sunlight resistance, excellent resistance to acidic discharge from oil burning ships.
6. ***Textile***	Spindle tapes and bands, jacquard strings, scouring tapes, heald yarns.	High strength, abrasion and flex resistance, stability to changes in atmospheric conditions.
7. ***Miscellaneous*** (a) Laundry	Laundry bags, press cloths, calander clothing.	High strength, abrasion and flex resistance, excellent resistance to heat and bleaching agents.
(b) Paper	Paper makers' felts.	High strength, abrasion and flex resistance, excellent heat and chemical resistance.
(c) Shoe	Sewing threads.	High strength and initial modulus of strength, low extensibility, excellent rot resistance.
(d)	Industrial sewing threads of all kinds.	High strength and initial modulus of strength, low extensibility, excellent rot resistance.
(e)	Industrial overalls and laboratory coats.	High strength, abrasion and flex resistance, excellent chemical resistance.
(f)	Laminates.	High strength.
	Canvases and coverings.	High strength, abrasion and flex resistance, good resistance to sunlight, immune to mildew and rot.

A QUARTER-CENTURY OF PROGRESS IN FORD PRODUCTION METHODS

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Presented to the London Graduate Section of the Institution, 28th September, 1954.

IN presenting this review of the progress in production methods which has been achieved by the Ford Motor Company in the past 25 years, it is essential to understand that the references are to the Company's achievements in England during this period, although a great deal of the initial approach and procedure was based on the Company's experience in the U.S.A. which had been gained in the early years of this century.

Inception

The Ford Motor Company began its manufacturing activity in England in 1912 under the title of Henry Ford and Son, and was concerned with the production of the famous—and what is now accepted as historic—Model T.

A factory was acquired at Trafford Park, Manchester, for this purpose and between 1912 and 1927 a total of approximately 850,000 vehicles was built. In 1927 a complete re-orientation took place in design and the result was the Model A, which was as radical a departure from its predecessor as the jet engine was from the piston engine. Production of this model commenced in 1928 and this was a vital year in the history of the Ford Motor Co. Not only did the Model A go into production, but two other events of outstanding importance in the Company's history took place. First, the Company was reconstituted to conform to its present structure, and the decision to move from Trafford Park to Dagenham was made. This decision was not only of supreme importance to Ford as a Company, but to the nation as a whole.

Those present to-night may find it difficult to appreciate the significance of this statement as they had not the good fortune (or misfortune—depending on one's outlook) to work in these critical times. But if one studies the industrial history of this period, the courage, foresight and wisdom of those responsible for this momentous decision assumes its true perspective. Industry and trade were going through their great climacteric, world conditions were unstable, industrial unrest was the order of the day, and it required men of great courage and determination literally to up-root an established business and relocate it on a site where everything was an unknown quantity. When one considers that to-day the Company employs 40,000 people, one can see immediately the importance of this event as part of our national life.

But for the purpose of the presentation of this Paper, this period also held the seeds of what has now become one of the main essentials of industry, namely —production engineering. Until this time workshop methods and processes had by and large been selected as a result of empiricism, and in most workshops it was left to the foreman or works manager to find his own solution. But the colossal demand for production during the First World War had started ideas to form in men's minds, and these ideas in the 1920's began to take shape in England and more particularly in the U.S.A. Until the latter years of 1920 the Ford Motor Company in England had no Production Engineering Department. It must be remembered that the factory in England was engaged in manufacturing the same product as the parent Company in America, and as the volume of production required in the U.S.A. was by far greater than that required in England, it was possible to accept the parent Company's planned procedure and adapt it to suit conditions in this country.

I think it would now be generally acknowledged that between the years 1906 and 1926 the Ford Motor Company in America was the pioneer of what we now call work study or production engineering. It was ahead of other organisations in its technique of work handling, work transportation, multiple processing, standardisation, time study, inventory control, and so on. This conception of manufacturing technique was quite revolutionary for

any industry, and it was in the natural order of things that the Ford Company in England based its practices and procedures on the same principles as the Company in the U.S.A. In later years it was a tremendous advantage to have had these formative years of experience as a base on which to build the present organisation.

This then was the inception of the Company in England, and represents in skeleton form its activities until the whole of the manufacturing was transferred to Dagenham.

The Pre-War Period

The period of development which forms the subject of this Paper can be divided into three phases—from 1928 to 1939, the War period, and the Post-War period from 1945 until the present time.

From its inception the Company had adopted the principle, which had been evolved by the Ford Company in America, of flow production and mechanically-motivated assembly lines. The technique of utilising special purpose machine tools and progressing the work in continuous sequence, which is to-day accepted as conventional practice for service production, was pioneered by the Ford Motor Company and was based on the simple principle which applies even more to-day than in those early days, "to produce the most work with the least effort, in the shortest time at the lowest cost".

Even in the 1920's the Company used multiple drilling heads, continuous broaching processes, rotary drum milling operations, multi-wheel grinding, roller and mono-rail conveyors, gravity chutes, and in fact many kinds of special purpose machine tools. A great deal of credit must be accorded to the machine tool industry in their willingness to co-operate with the Company and to utilise the whole of their imagination and resources in an endeavour to meet the demands of the Company for this specialised equipment. Possibly the first major step forward from this point was around 1928 with the introduction of carbide as a cutting medium on a large scale. Carbides of course had been in use for some years previous to this, but now they were becoming commercially practicable for use in large scale production. This fact has since become of historic importance as the whole technique of metal cutting was revolutionised. Speeds and feeds far in excess of those used previously were now possible, and the Ford Motor Company was among the first to realise the importance of this new agent and to develop its potential. It was soon obvious that the design of machine tools themselves required modification to utilise this new technique, and machine tool manufacturers relied on the experience of firms like Ford to enable them to carry out the necessary design modification. To the present generation, of course, the use of carbides is accepted as conventional practice as readily as the use of radio and television, but a quarter of a century ago it was as revolutionary to our industrial life as radio and television have been to our social life. Not only did this extended use of carbides enable parts to be machined at higher speeds; it also enabled the designers to specify materials in the higher Brinell ranges which, of course, reflected in the quality of the product. It was possible by using materials of greater hardness in many cases to reduce the section so that for equal strength there was a reduction in weight.

However, there were problems as well as advantages. As I have said, it was found in many cases that machine tools which had been quite satisfactory on high speed steel were not suitable when using carbide. It became necessary to re-design spindle construction, to enlarge and re-dispose bearings, to pay attention to chip disposal, to strengthen and improve slideways, and above all to increase the horse power. Major problems of re-grinding and honing the tools were set up and it was necessary to alter cutting rakes and angles. This involved machine tool and abrasive manufacturers in much research and experimentation in an endeavour to take full advantage of the potentialities of the new cutting medium, and as we all know the battle was not won over-night. It was, however, as I say a major step forward and marked the beginning of real progress in production methods 25 years ago.

The Transfer to Dagenham

As I have said previously the Ford Company in England had no Production Engineering Division, as such, during its activities at the Trafford Park site, but with the decision to re-locate the works at Dagenham it became imperative to create a department to specialise in the planning of processes and the specification of machine tools. This was necessary for two reasons. First, it was intended to manufacture products distinct from those of the American Company and for which there was no established procedure, and secondly, the magnitude of the works at Dagenham would in a period of years be considerably greater than the Trafford Park organisation. The nucleus of a Division for this purpose, therefore, was initiated in 1929 preparatory to the move to Dagenham.

The transfer of all activities to the present site began in the mid-summer of 1931, and was a completely successful operation of organisation and co-ordination. Lines of production machines which had been producing in the Trafford Park plant were producing components at Dagenham 48 hours later. The plant itself had been conceived as a complete production unit, and although it has now been in operation for nearly 25 years it is believed to be the most completely efficient factory of its kind in Europe today. It was erected on reclaimed marshland and necessitated the driving of thousands of concrete piles to form a suitable foundation. It has direct access to the River Thames, complete with its own jetty and facilities for unloading raw materials or shipping finished products to all parts of the world. It is self-contained in respect of all services, for lighting, heating, power, steam, water and gas. The iron required for the foundry is produced in

the Company's own blast furnace, and the coke and gas necessary for the blast furnace are supplied from a battery of coke ovens which form part of the complete production unit.

All of this is now accepted as part of our industrial life, but it is as well to remember and emphasise that the conception of all this was due to a handful of men who had vision and determination and who have lived to see their ideals come to fruition.

The production of the Model A which had been carried on at Trafford Park during the preceding two years was continued at Dagenham, utilising the same plant which had been used previously. Concurrent with this continued production of the Model A, the Design Division was busily engaged in the preparation of two passenger cars which eventually were to find favour in most of the world markets. These were the Models Y and CX, the 8 and 10 h.p. cars which eventually formed the basis of the original 'Anglia' and 'Prefect'.

I have already said that the nucleus of a department to handle production engineering problems had been started before the Company left Trafford Park, and when the transfer to Dagenham was made this department was much expanded to deal with the new circumstances which were foreseen. Men with imagination, academic qualifications and a good deal of workshop experience were recruited from the works personnel, and to them was assigned the task of planning the manufacturing procedure for the production of the new range of cars. It was now that the planning experience of the Associate Company in America showed its advantages. It was possible to follow in principle the same procedure which had been so successful in the States. Each production engineer was given a specific assignment for one or more departments depending on the nature of the assignment. For example, one engineer was responsible for the manufacturing procedure of cast iron parts; another for rear axle driving gears and pinions; another for engine parts such as pistons, connecting rods, etc.

Planning Procedure

Although the planning procedure has undergone a good deal of refinement and revision in detail, the basic approach has remained the same and in substance operated as follows in the initial stages. As component drawings were received they were routed to the respective engineers who had been assigned to handle the various parts. The engineer would then proceed to plan a complete sequence of operations for the individual items in such a way that he achieved the maximum amount of work in one handling. At the same time he would be guided by the principle of simplicity and practicability so that the machine tool would not be unnecessarily complicated. A typical example would be a vertical column machine with a horizontal rotary indexing table for dealing with a component which had, say, a cluster of holes requiring drilling, counter-boring, reaming and spotfacing. If the cluster comprised four holes this machine would, therefore, carry out 16 operations at one loading and with one operator, and the mechanics of the machine would not be unduly complicated. This grouping of operations meant that the line was enormously productive, and 25 years ago the number of firms who tackled their production along these lines was very few, particularly outside America. As the engineer completed the planning procedure the published information was sent to the Jig and Tool Design Section who, in co-operation with the engineer, would scheme out suitable work holding and tooling arrangements with three main essentials in mind: to use a positive foolproof location, to attain the maximum feeds and speeds and to achieve the simplest method of loading, clamping and unloading.

A Fundamental Principle

There was one fundamental point which was vital to the successful operation of this type of layout. The Company had never agreed to bargain with its employees on the amount of work which was expected from any operator. It was, therefore, understood by any employee from the day he started on production that he might be expected to operate two, three or even more more machines. This principle was absolutely basic to the successful working of the Ford idea of machine layout, as it meant that all the precision required would be built into the machine tool and its auxiliary equipment, and it was only necessary in the majority of cases for the operator to load and unload, keep the location points free of swarf and press the starter button. With this arrangement, the whole of the operator's time could be usefully employed which was a most important factor in minimising cost. Concurrently with the publishing of the operation layout to the Jig and Tool Design Section, a copy would be sent to the Plant Layout Section and to the Inspection Department. It was possible for the Plant Layout Section to determine from this layout the sequence in which the machine tools would require siting, and by the use of scale templates they would prepare a scheme for approval. This scheme would require approval by the Production Engineer, the Time Study Department and the Works Superintendent, to ensure that the work would flow to the best possible advantage and utilise the most economical labour distribution.

While this was being prepared the engineer would circulate to the machine tool industry a detailed specification of his requirements for the necessary machine tools. This enquiry was not confined to the manufacturers in England, but was also sent to Continental countries and the U.S.A. This meant that the latest and most original ideas from world sources were available and ensured that the most productive and up-to-date equipment could be acquired.

The copy of the operational layout which had been sent to the Inspection Department would be studied by them to determine where it was necessary to supply individual process gauges. It has always been standard practice with Ford's to have a series of check gauges at various stages during the sequence

of operations. This is a form of quality control so that any deviation from specification can be detected as the work progresses, and enables remedial measures to be taken at the right moment. This precaution means that parts are maintained to standard specification at all stages and keeps the machine scrap to an absolute minimum.

It will now be appreciated that at this point a positive position had been reached in the operational plan. An agreed sequence of operations had been devised, the Jig and Tool Design Section was able to proceed with design and drafting of equipment, machine tools enquiries had been invited from the most experienced manufacturers, the Plant Layout Section was able to prepare a scheme for siting the machines, and the Inspection Department was able to specify the necessary gauges.

With reference to the Inspection Department it is worth noting that it has always been Ford practice to make this department responsible only to the Managing Director. The Chief Inspector, therefore, is not influenced by any demands from the Works Manager. This is believed to be a sensible and logical arrangement, as it enables him to have a degree of independence divorced from any necessity to consider production output at the expense of quality.

This, then, was the procedure in broad outline which obtained for the planning of manufacturing processes when the first 8 and 10 h.p. cars were about to go into production. Later, I will indicate some of the detailed refinements which have been introduced into the planning procedure in recent years as a result of the experience gained in the early stages at Dagenham.

Types of Machines Used

Now let me indicate to you some of the types of machine tools and processes which were current during the production of the first range of passenger cars at Dagenham. Probably the machines which were outstanding in these years, and which had been developed almost exclusively by the Ford Motor Co. in America, were the rotary drum milling machines which were used on cylinder blocks, manifolds, front covers, cylinder heads and other components which required milling on two parallel faces. For those who are not familiar with this type of machine, it consisted essentially of a main rectangular frame. Through the centre of this frame and running on bearings in the frame columns was a large diameter shaft to which was anchored a circular casting resembling a large drum and on this, in turn, a series of fixtures was mounted to carry a number of components. In each side column of the machine were three sets of cutter spindles arranged to carry rough, semi-finish and finish milling cutters. While the cutter spindles rotated the centre drum also rotated, so that the operation became a continuous milling process. The output from a machine of this type was considerably greater than from any other type of conventional milling machine. Where the normal feed rates on standard machines was perhaps 8″ or 10″ per minute, the feed rates on the rotary drum mills was of the order of 20 i.p.m. and in addition there was no lost time for loading and unloading as this was achieved during the cutting cycle. Some of these machines are still in use and giving excellent service, and although we now have other milling machines which are considerably more productive, these rotary mills are still far in advance of many standard milling operations utilised today.

For the semi-finish grinding of crankshaft main bearings we used grinding machines which were fitted with four grinding wheels, so that all the bearings were ground simultaneously. These were equipped with a dial indicator gauge which made contact with the face of the thrust bearing, so that the operator, by moving the work table according to the reading on the gauge, could bring the crankshaft into correct relationship with the grinding wheels.

A centreless grinder which was used for grinding cylinder liners was fitted with eight grinding wheels. Each wheel was dressed in such a way that it was a few thousandths bigger in diameter than the preceding wheel, so that as the work traversed through the machine as much as .010″ to .015″ was removed in one pass. The difficulty with this machine was in maintaining the concentric running of all the grinding wheels and the length of time necessary to change over the wheel mounting when the wheels required changing.

Perhaps some of you remember that in the original 'Anglia' and 'Prefect' engines the valve guide bushes were of the split type, that is, the bush consisted of two halves, and the machine which was used to rough cut the radius of each half was enormously productive. It was a continuous broaching process developed by Ford, and with up-to-date improvements there are many of these machines being used in America today. It consisted of a cast iron bed to which was attached a tunnel type broach holding fixture. A form broach was secured inside this fixture and a series of small work holders in the form of a chain was driven through the tunnel. The operator dropped one half of a valve guide bushing into the work holder and the continuous chain pulled it past the broach. The joint face and the radius were thus machined, and the component dropped into a bin at the finishing end of the machine. Many of the machines used on the cylinder block lines were what is known as "Way" type machines and in some cases had drilling heads arranged in 3, 4 or 5 planes. Some of these special purpose machine tools carried up to 60 or 70 spindles, and a single line would produce up to 300 cylinder blocks per day.

Expansion of Production

During this period the factory was growing at a tremendous rate. Component parts which on previous models had been purchased from outside suppliers or imported from U.S.A. were now being scheduled for manufacture at Dagenham. This created a great demand for new special purpose machine tools of a type which had not been manufactured previously in this country. The machine tool industry in

England responded magnificently. They were eager and willing to co-operate with Ford in this respect and to avail themselves of the great experience which the Company had had through its American associations. Many companies were aware that the pattern which Ford was weaving must of necessity be followed by other organisations in the next few years. And it was not only the Ford Company itself which gave this impetus directly. Indirectly, through its sub-contractors, new methods were being evolved. These sub-contractors had open access to the works and they saw the value of the type of production methods employed by the Company. If they were to continue supplying parts economically, it was obvious that they would have to introduce similar procedures. So the machine tool industry was involved in supplying special purpose equipment to many of the firms who were acting as vendors to Ford.

An Erroneous Belief

But it is quite erroneous to believe that production methods consist only of metal cutting operations. It was equally important to give attention to many other aspects closely connected with production, the design of the individual parts for example. Crankshafts and camshafts were cast instead of forged, connecting rods were forged with the studs integral. Many parts were fabricated by the flash butt welding process instead of being forged in one piece. Designing for the most economical production became a highly skilled art, and the people associated indirectly with production had to play their part. Progress departments which are now part of any modern industrial organisation is an extension of the idea which Ford introduced and which were originally designated " Production Stock Chasers ". With lines of machines consuming parts at enormous speed it was of vital importance that no hold up should occur in waiting for material to be fed to the lines. It was the duty of those stock chasers, therefore, to see that this material was always available, to ferret out any hold up at the source, to inform the Purchase Department of any likely shortage of " bought out " parts, so that steps could be taken to remedy any deficiency. Many times in those early days it was not an uncommon thing for a chaser in the Purchase Department to go out in the middle of the night with a lorry to bring in supplies from sub-contractors so that there would be no hold-up on the production lines the following day. And although it was a major error of omission to be involved in a shortage, it was equally a major error of commission to have too much stock on hand. The factory was expanding rapidly, and as profits were earned they were pumped back into the business to expand even more. The Company, therefore, could not afford to carry excessive stocks in those days, as this in effect meant a lot of expensive material lying dormant. Business then was not as it has been in the past few years—obtained without being sought; it had to be fought for every inch of the way. Everyone had to be literally on his toes from the Managing Director to the office boy. There was no excuse for inefficiency. There was no question of " it can't be done " but " it *must* be done ". A white collar did not qualify anyone for privileges. If circumstances demanded that anyone should work on through the night, then they did just that. Every facet connected with manufacturing was put under the microscope, because all the time the drive was towards more and more efficiency. Tool usage was closely investigated, raw material sizes were kept to a minimum to avoid undue waste, optimum feeds and speeds on machine tools were utilised, close tolerances had to be maintained to enable parts to be assembled at the rate of 30 or 40 assemblies per hour, holes were cored in castings where it would speed up production and for the same reason holes were pillaged in forgings. High speed electric tools were used for assembly work, and in fact horse power was used wherever it was economical.

With regard to machine tools a good deal of standardisation was carried out. A good example was the standardisation of electric motors. It was foreseen that eventually there would be thousands of machine tools in operation in the plant, and it would be quite impossible to maintain production in cases of emergency if a mixed batch of electric motors was used to power the machines. A thorough study was, therefore, made of all the motors made in this country and eventually the product of one firm was selected as having all the desirable characteristics. A full range of this type of motors of all horse powers was specified as standard and that standard has been maintained until quite recently. Now, of course, the electrical industry have agreed on a B.E.A.M.A. standard and this will be used in future. However, the example will serve to show the importance of one aspect of standardisation, as without this principle a considerable loss of production could have been involved in case of a breakdown until a suitable motor was obtained. Of course, this sort of precaution today is known as " Preventative Maintenance ".

Continued Growth

And so the plant continued to grow. The blast furnace was producing more and more iron, more reels were installed in the foundry, a rolling mill was introduced to produce bar sections for the automatics, and all the time new ideas were being brought in. Everyone was encouraged to utilise his talents; if a better way was suggested for doing a job and it seemed practicable it was tried. Of course, there were failures, mistakes were made, wrong conclusions were arrived at, but all these did not stop the flow of ideas. A vast experience was being accumulated and was eventually put to good use.

Even the machine tool suppliers had a hard road to travel to face up to the exacting conditions imposed. If a machine tool was purchased with a guaranteed performance and it failed to achieve this, the supplier was not allowed to avoid his obligations. It was necessary at times for suppliers in some cases to spend weeks and even months in developing his product after it had been delivered to enable him to attain the performance he had guaranteed. The shortage of business in the machine

tool industry during the middle thirties was such that some manufacturers were at times inclined to be a little over-optimistic and to specify a performance which they would eventually find difficult to maintain. It could, of course, be said that the engineer who agreed to the specification should have known in such cases that the proposed output could not be maintained and this is true. But engineer and machine tool builder alike were being brought up the hard way. They were each getting first-hand experience of problems that were new to them, and the nett result all round was on the credit side.

It was tough going from 1931 until about 1936. The cost of running a factory of this size was colossal, and as fast as the earnings rolled in they were expended on wages, suppliers' accounts and equipment. But after these five years the results began to justify all the effort and endeavour. Sales began to grow, efficiency had increased all round, manufacturing costs were reduced, in a highly competitive market the Company was able to keep its prices lower than any of its competitors, and in fact the whole organisation was now solidly based and flourishing.

And so from 1936 to 1939 was a period of expanding and consolidating what had been achieved in the five previous years. The products were improved in performance and appearance. The V8 - 22 and V8 - 30 passenger cars had replaced the Model A. A range of trucks and vans was in production, and the tractor plant which had been transferred from Cork was turning out its quota. It was during these years that the Company was able to supply the motorist with the first and only £100 car in the history of the country. Even in those days, when values were entirely different to what they are today, this was a terrific achievement. Approximately 10,000 employees were engaged on regular and well paid work. Everything was going as planned and the future looked bright, and then almost out of the blue — tragedy !

The War Period

The country found itself at war. What about the future now?. The bright prospects of a few months before had disappeared over-night, and the livelihood of 10,000 people was in the melting pot. It was obvious, of course, that the country would require a colossal number of vehicles, but they would not be the kind which the motor industry had been producing until then. However, like the other major producers of motor vehicles in this country, it was not long before the Ministry of Supply and the manufacturers had hammered out a plan which would ensure that each of their resources would be used to the fullest extent for the national well-being. But even in this scheme Ford's were requested to undertake an assignment which was most surprising, to say the least. They were requested to erect, equip and run a factory for the production of Rolls-Royce Merlin Engines. This was indeed a departure from the days of the "Tin Lizzie"—the finest piston engine in the world to be produced by a company which had manufactured the world's cheapest car.

The history of the Ford Motor Company during the War period, therefore, consisted of two major assignments, the production of military service vehicles at Dagenham, and the production of aircraft engines at Barton, Manchester. First let us look in retrospect at the achievement at Dagenham. The first problem was one of expediency. It was obviously impossible to design a new range of vehicles which would be acceptable to the Services in a few months. Modifications to existing designs were, therefore, submitted as a temporary solution and these were accepted. There was a demand for the 30 h.p. V8 engine for marine craft and also for some versions of the Bren carrier. It will be appreciated that this involved a good deal of retooling of existing plant as passenger vehicle production dropped to almost zero. To provide more capacity on the truck sections many of the machines which had been utilised on car production had, therefore, to be retooled for military trucks.

A Potential Hazard

In the event of Germany carrying out intensive bombing operations on British industry in the early months of the War, the Dagenham site, which had been selected on account of the advantageous position with regard to river and sea transport, was in effect a potential hazard. It was on a direct line of action for enemy aircraft operating in the London region, and with our air defences as they were in the last few months of 1939 it was a sitting target for the Luftwaffe. However, providence was on our side and by the time Germany began her intensive raids the R.A.F. was well enough equipped to give full protection. In fact, after four years of warfare it was indeed a miracle that the factory had escaped with so little damage. But like everyone else in the country we were not to be deterred by any thought of personal risk. The Company went ahead building its first phase of the military truck programme, and our next assignment at Dagenham was to undertake the production of a version of the Bren carrier, and in this connection there were one or two interesting features. The particular model which we were going to produce was already in production in the works of other manufacturers. For many reasons it was not possible to utilise special purpose machine tools to the extent that had been current with our domestic models; consequently the whole of our technique had to undergo a change to reconcile ourselves to the new conditions. For years we had been organised to produce hundreds of the same product every day, and now the whole of the country's war effort was very much of an improvised nature and changes were taking place almost every day. We had many machine tools lying redundant and our first consideration was to employ those to the fullest extent. Many hundreds of machines which had been fitted with special equipment were stripped and retooled for their new duty. We were fortunate in that the V8 30 h.p. engine had been specified by the Services

for use in Bren carriers and this meant not only a continuity of our production in this respect, but indeed a great expansion in production for this unit.

But this was all very wonderful experience which we were gaining, and with due modesty we say we were giving as a result of our previous knowledge. The production of the Bren carrier was a case in point. I have said that other factories were already in production on this vehicle and it was obviously in the country's interest that we should avail ourselves of these companies' experience to enable us to get into production in the shortest possible time. We therefore elected a delegation to visit these factories and to study their production procedure. It was quite revealing to see in the three factories which we visited that the predominant approach had been along the lines of general machine shop practice. Standard vices were used on milling operations which meant that each work-piece had to be accurately set at the beginning of each cycle. Radial drills and centre lathes were the order of the day. It was unusual to find any special tooling layouts, and nearly all the machining operations were carried out by skilled operatives or at best trained dilutees. But the most surprising thing was to find an army of fitters working along the assembly lines. Filing, chiselling and scraping seemed to be part of the accepted technique and it was obvious that as for the most part our productive labour was unskilled, we should have to approach the problem differently.

The First Step

The first thing we did was to take every single production drawing and redimension it, not to increase the allowed tolerances but in most cases to tighten these up. If these vehicles were to be assembled at the rate of 50 or more per day by unskilled labour, it was obvious that the control of tolerances in production was such as to enable the parts to be assembled without fitting and that any one part was interchangeable with its counterpart. On the machining side, although we used only standard machines, we tooled these in such a way that any operator after a few hours' training could produce parts to specification. Special fixtures and tools were designed and manufactured, gauges to set the tools were provided whenever necessary. The types of machine tools in use were kept to a minimum, and a planned schedule to change over any machine from one part to another was developed. Alterations to forgings and castings were requested in cases where it would simplify production. A typical example of how a method could be simplified was the cross tube which was mounted under the hull to carry part of the bogie. This tube had a rectangular block mounted about 12" from each end, and the practice in other works was to press these blocks into position and then grind the four faces of the blocks true relative to each other. It was first decided that these blocks would be ground to finished dimensions and then the ends of the tube immersed in a liquid air container. This would shrink the tubes and allow the finished blocks to be slid into the reduced diameter, at the same time maintaining the correct position in a special fixture. This was tried experimentally and proved successful. It was then suggested that as the cost of liquid air would be expensive and the supply doubtful an alternative process, but fundamentally using the same principle, should be tried. Instead, therefore, of shrinking the tube, the blocks were heated to about 450°F. which expanded the bores sufficiently for them to be assembled in the special fixture, and this method was used until production of this model ceased towards the end of the War. In fact, some of the other manufacturers adopted many of the methods which Ford introduced on this Bren carrier production.

At about this time also we went into production with a four-wheel drive truck which we had designed and which had been approved by the authorities. The production technique for this vehicle followed the usual Ford practice, although the quantities did not justify the exclusive use of special purpose machines which car production had warranted. Nevertheless the factory by this time was turning out a considerable amount of production. It was getting back into its accepted rhythm and the labour force was growing each month. And so the Company at the Dagenham factory continued until the end of the War, manufacturing trucks, Bren carriers and a large quantity of engines for a variety of purposes.

And now I would like to give a brief outline of the Company's achievement in producing the Rolls-Royce Merlin engine. This was, indeed, one of the purple patches in Ford history. To be quite candid, when the news was first announced many industrialists openly scoffed at the idea. It was inconceivable that Ford, although acknowledged to be paramount in the production field, could undertake such as assignment, as it was so fundamentally diverse to its previous experience. But the doubtors failed to take into account the calibre of the men who ran the Ford organisation. The Company's position in the industrial field, although it was attributable to its engineering and production staff, stemmed essentially from its top level management. These were the men who had the courage, foresight and determination to transfer the plant to Dagenham in the first place, and it was these same men who had the ability and confidence to pledge themselves to an undertaking which they knew in many ways would be tougher than anything they had ever tackled, but who did not for one moment waver in their confidence or their ability to carry out their mission successfully. And to one man in particular must go much of the credit, to the present Chairman of the Company, Sir Rowland Smith. What Sir Winston Churchill was to England, Sir Rowland Smith was to Ford in those crucial days. Mr. Hilary St. George Saunders, who wrote much of England's War history, also wrote a book entitled "Ford at War", and it is interesting to quote a few lines of the conversation between Sir Wilfred Freeman, Air Chief Marshal, and Sir Rowland Smith, in their initial discussion relative to the manufacture of aircraft engines.

Mr. Saunders says, in his book, that Sir Wilfred leaned across the table and said: "We want to know if you will make Merlin engines for the Air Ministry" and Sir Rowland's rejoinder was "How many do you want?"

"Four hundred a month."

"Right!" said Sir Rowland.

"How much will it cost?"

"My guess is seven million pounds" replied Sir Rowland. And his estimate proved to be singularly accurate. The cost of building and equipping the factory eventually cost six-and-three-quarter million pounds.

Importance of Personnel

As we can well imagine, a decision of this magnitude could be, and indeed was, made in the space of a few hours, but the implementation of such a decision took many, many months. The first and most important factor would be the selection of the personnel who were to act as a team to lay the foundation of what was to become a vast organisation. They would act as the spearhead, the driving force, and the sheet anchor on which the enterprise would depend. They would supply the knowledge, experience and skill as a base on which to erect the subsequent structure. At the same time the factory at Dagenham had to be left staffed to deal with its assignment. Approximately 30 men were originally selected to supervise the planning, engineering, building and equipping the factory, and this figure was later expanded to about 190 to supervise, organise and run production and to train all the operatives involved. The eventual plant strength reached approximately 15,000 and was responsible for the production between 1941 and 1945 of more than 30,000 complete engines. This undertaking gave Ford the opportunity to demonstrate that its production methods could successfully be applied to a product of this nature. Skilled labour was at a premium throughout the country, and it was patent that trained engineering staff would only be used on jobs where it was absolutely essential, such as production engineering, jig and tool design, tool room, etc.

The previous experience of the Company now became of incalculable value and the production technique for every single component was so arranged that the operators could undertake their duties after only a few days' training. In fact, about 40% of the plant strength consisted of female operatives and it says a great deal for the care and thought which went into the operational layout that these operatives were able to produce work of such a high standard. Processes followed the flow production technique and the precision was built into the machines and tooling so that the degree of skill required from the operator was the barest minimum. The success of the enterprise, therefore, resolved itself into first class production planning, the most advanced jig and tool design and excellent supervision. These were the criteria which determined the successful implementation of the scheme, and eventual results more than justified the confidence in the originators of the proposal. It must be remembered that a good deal of the work which was handled was of such a character that it was outside normal Ford experience. Crankshafts, for example, were forged from high duty materials and necessitated the removal of considerably more material than the normal Ford cast crankshafts. Aluminium alloys were used extensively and experience of machining these materials was at this time not extensive. Attention to the quality of surface finish and the maintaining of radii tolerances were other things that needed great attention. These may seem rather elementary and insignificant today, but it must be remembered that techniques had to be evolved to enable such processes to be carried out by unskilled labour, in many instances by personnel who had had no factory training at all. And it was not only the actual operation of the machines which they had to understand, they had to be made conscious of the importance of the work being maintained to a specified standard. Too many lives depended on the ultimate result, and final success was due not only to Ford. The Rolls-Royce Company themselves were unremitting in their endeavour to provide all possible information and pass on the result of their many years of experience. The Air Ministry Inspectorate were likewise only too glad to make available all possible information, and the co-operation all round was of the order that is seen too seldom in industry. The exchange of information was always readily available and freely given, and the final result was worthy of the efforts of all concerned. It was a great experience for Ford. They brought the whole of their previous experience to bear, but equally they in turn accumulated a vast store of knowledge and experience. And so, for five years of assiduous and unrelenting effort, Ford played its part in the national interest and contributed to the final victory.

The Post-War Period

And then, paradoxically, 1945 was a repetition in some respects of 1939. Hostilities were at an end, the mental and physical strain was relieved, everyone of us was thankful that such a terrible phase had been survived. But what of the future ? The pattern of the world had altered, the country's resources and credit had been expended. Now it was a question of national, international and individual rehabilitation. Just as in 1939 the plant had to be reorganised in the national interest, so now it had to be reconverted for the same reason but with a different objective. Would we be able to retain our old markets, open up new ones? Would our products find a ready sale, what had we learnt in regard to design and manufacturing during the War?

These were the questions that had to be resolved by industrial organisations in every country in the world. The paramount need was at least to get back to a point where we had left off in 1939, to establish and consolidate what we had achieved before the War and, while this was being done, to assess our needs for the future and plan accordingly.

In one respect the Company was very fortunate. The country's food position during the War had been perilous and the Government had encouraged and supported our tractor programme as part of the national emergency. Britain's farms had become more mechanised than at any time in the country's history. Realising the need for even more productive farm equipment, the Company in 1943 approached the Government for permission to go into production with a new design of tractor which was more productive than any existing model in this country. The Ministry of Food supported the scheme and production had just commenced on this tractor in 1945 when the War ended. There was a world shortage of farm equipment and this tractor found a ready market.

Getting Back to Normal

The rest of the plant necessitated immediate reconversion to its basic products, 'Anglias', 'Prefects' and civilian trucks. After five years of intensive effort it was natural that everyone should want to relax slightly, to readjust themselves to the new conditions. Employees who had been in the Forces were now returning to industry. Women operatives had done their duty and in many cases were glad to get back to their domestic routine. But it was soon obvious that there was no time to relax, that tomorrow would be too late and that whatever the difficulties, the sooner they were tackled and overcome the better it would be for everybody. So, after many months of intensive effort, the factory began to get back into its stride.

Through the years 1946, 1947, 1948 and 1949, production expanded, quality improved, materials became more plentiful, costs and prices were reduced and then, in 1950, a new phase of Ford history opened. The Design Division had been extremely busy since the end of the War designing and testing a new range of cars. Our market research had indicated the features which would be in demand, and as a result of more than three years' effort the 'Consul' and 'Zephyr' range of cars came into being. This gave the production engineers an opportunity to introduce new methods and processes. It was now more than 10 years since the major tool-up had taken place and much had been learnt during this time.

Changes in detail were introduced into the planning procedure. All time-consuming elements in the work cycle had to be calculated in advance to show the estimated production of which any machine would be capable. Speeds, feeds, indexing time, loading, unloading, gauging, de-swarfing, tool changing, etc. All these elements required study to enable a true assessment to be made of the potential output.

Cost Consciousness

But still more important was the degree of cost consciousness which permeated the whole organisation. It was the responsibility of the production engineer to analyse every aspect of the design of the individual parts from a manufacturing point of view. In every case where a process could be simplified by redimensioning a part, this had to be brought to the attention of the designer and the manufacturing advantages pointed out to him, providing it did not conflict with the functioning of the product. We had always considered ourselves most efficient in manufacturing processes, but now we began to question whether in some directions we were less fitted to manufacture certain components than our trade suppliers. The source of supply for a large number of items was determined by automatic selection. Due to the complicated processes on items such as cylinder blocks, crankshafts, transmission gears, cylinder heads, etc. and to the methods we employed for manufacturing such items, we knew that such items could not be purchased economically. Conversely, parts such as tyres, batteries, glass, etc., were more economically produced by our suppliers as they were supplying similar parts to the rest of the motor industry. But there was a large number of parts which could equally well be obtained from either source but which we had manufactured previously without question. It was these items which were put under the microscope and subjected to a comparison in cost between the two sources. A very detailed study was introduced which involved the production engineer and cost accountant taking into account all the factors which influenced the final cost: capital expense, manufacturing expense, special tools, floor area, overheads, return on investment, volume life of the product, quality, consumable tools, utilities and policy. As a result of this we found much that was interesting. We were satisfied that our methods and general efficiency were satisfactory, but in some cases we found that they were not necessarily economical. For certain types of parts our manufacturing costs and overheads could not compete with the smaller specialised industrial units, and accordingly our programme was streamlined to conform to this new pattern. The parts which we had to manufacture at Dagenham, however, enabled us to introduce the most up-to-date methods and this was carried out after much thought and care.

A Typical Example

A typical example was the cylinder block for the 'Consul' and 'Zephyr' engines. As you all know, these are four and six cylinder engines respectively, and it was our intention to process these down the same production line. This involved a good deal of mutual co-operation between the designer, the production engineer and the machine tool builder. Essentially it meant that all dimensions for the two blocks had to be the same in respect of each other in relation to whichever end of the block was leading in the line. As it was necessary on occasions to turn the block longitudinally through 180°, it will be appreciated that this involved many complications. But these difficulties were surmounted and a practicable scheme was devised.

But our main objective in tooling up for the 'Consul' and 'Zephyr' cars was to reduce the amount of

labour per production unit and to increase the rate of metal removal. It was obvious by now that labour would be at a premium for some years to come and that the War had accelerated machine tool design, particularly in respect of faster feeds and speeds. In America, machine tool builders had successfully developed transfer machines, and after a great deal of study we were satisfied that this was a logical method for large scale production. It was our experience that in a good many cases is cost as much to handle the work as it did to carry out the machining operations. Every time an operator manually handled a component to move it to another machine it cost money, and achieved precisely nothing in terms of production.

Using the Transfer System

We therefore decided that where it could be economically applied we would use this transfer system for our new products. You will notice that I have said "where it can be economically applied". I wish to make it clear that the transfer machine is not the answer for any and every type of series production. A very careful study must be made of all the factors which affect the final cost, particularly the capital cost, in relation to volume required. In the case of which I am speaking, these factors were favourable and we proceeded with our planning accordingly. This production line has now been in operation for more than four years and it has fully justified all our anticipations.

A general description of the line will be of interest, as it is believed to be the most productive line of its type outside of the U.S.A. The first operation is to mill four location pads on the manifold side. This is carried out on a special Cincinnati mill which employs a travelling milling head. The workpiece is pushed on idler rollers into the fixture and automatically located and clamped. The milling head carries two spindles spaced 8" apart, and when the starter button is pressed the head trips into quick traverse then slows down to cutting feed for the first two pads. It then travels at a faster rate to do the next pad position and again slows down to milling feed for these pads to be machined. Finally, the head returns to the starting position at the faster rate. As the block is ejected from the machine, the operator pushes it along a roller track to the machine which is used to mill the cylinder head and oil pan faces. When the block is pushed into the loading fixture and the cycle switch has been initiated, the workpiece is clamped and the fixture rotates 90°. This allows the block to be loaded onto the transfer rails, these rails being positioned relative to the milled location pads which were machined in the first operation. The transfer bar then engages on the flywheel housing end of the block and pulls the workpiece along the transfer rails into the first milling position. It is then automatically clamped in position on the rails by vertical hydraulic plungers, and being secured in position the milling unit for rough machining the cylinder head faces traverses at a rate of 54" per minute to mill this surface. As this is completed, the transfer bar again comes into operation and carries the block into the next position where the oil pan face is rough milled. Concurrently, a new block has been placed in the loading fixture and as the transfer bar pulls the first block into the second position it also pulls the new block into the first position. Altogether the machine has seven stations for rough and semi-finish milling head and sump faces and bearing cap, and in addition drills and reams two dowel holes. If these were each done on separate machines it would account for 13 operations, but on this machine this work is carried out by one operator, simply by rolling the work into the loading fixture and pressing a starter button. After milling the end faces in another transfer machine, the work moves into the drilling section, and as in each of the individual transfer machines it is only necessary for the operator to push the work into the starting position and initiate the cycle. The work therefore moves in this manner from one machine to the next without being lifted manually. Between machines it is rolled along on an idler roller track and in the various stations of the individual machines it is mechanically traversed. Where it is necessary to elevate or rotate the workpiece it is again achieved mechanically, so that manual effort is reduced to the absolute minimum.

Comparison with Previous Methods

This, then, is one example of Ford's progress in method since the end of the War and it is representative of many other examples. And how does it compare with a previous method for a similar component?

On a cylinder block having comparable operations which was tooled in prewar years, we employed 86 operators on two shifts and produced 600 parts. On the present line we employ 44 operators including supervision on two shifts and can produce 900 parts.

Let us take another example. Before the War we used three separate machines to turn the main bearing diameters, the flange diameter and the pulley diameter on the crankshaft. Now these three operations are combined on one machine. It has been our constant endeavour to reduce manufacturing costs by unceasing attention to improving all of the factors which contribute to such costs, speed of cutting, reduction of handling time, minimising stock removal, better cutting tools, conservation of materials, in fact anything which can be considered as inefficient. We have made a good deal of progress, but there is still a lot more to do.

This, then, is the degree of progress made by Ford in the past 25 years, from the 'Model A' to 'Consuls' and 'Zephyrs,' from approximately 4,000 employees in 1928 to 40,000 employees in 1954. We are only part of a very exacting and competitive industry. We believe that the degree of progress which we have made is attributable to every section of the organisation, that every individual must play his part, and that the division of responsibility must be clearly defined so that every department carries out

(concluded on facing page)

Aircraft Production Conference 1955

Mr. W. S. Hollis, B.Sc.(Eng.), A.F.R.Ae.S., Assistant Director, Aircraft Production Development Branch, Ministry of Supply, writes:

Much of the time at this year's Southampton Conference was devoted to discussion on methods of integral construction of aircraft parts and perhaps we should not conclude the Papers without recording, on this subject, an appreciation of the collaboration and help given by the counterpart organisations of engineers and technicians of the American aircraft and associated industries.

In the study of this method of fabrication, they have invited us to their Symposiums, welcomed us to their firms. Their machine tool industry has always made available any information. They have loaned us models of their large presses and sent their top engineers to lecture on them so that we could better understand their approach to the problem and fit our own needs to it.

Theirs has been a wider experience which has set our standards of comparison for all forms of integral construction.

I am sure that all members of British investigating teams would join in this appreciation and, perhaps, at the meeting which attracts the greatest interest among all branches of British aeronautical science, this is the place to record it.

A QUARTER-CENTURY OF PROGRESS IN FORD PRODUCTION METHODS—*(concluded from facing page)*

its duties efficiently. The successful operation of the manufacturing departments must, of necessity, stem initially from the degree of efficient and up-to-date methods which are specified. At the same time, methods are not revolutionised overnight. What is current today will assuredly be obsolete in a few years. All progress is the result of experience and the utilisation of knowledge. It is simply a matter of knowing what resources are available and utilising these to the best advantage. If we can study a piece of production equipment which is available and by general discussion and the interchange of ideas we can improve on the original, that is a step forward.

We believe that we have learnt much during the period of our existence and we have always been willing to show to industry anything from which they may benefit. On the other hand we believe that we, ourselves, can learn from other people. We have excellent relations with other manufacturing organisations, even our competitors in trade, and we are not reluctant to visit their works and discuss common problems, and we think that by doing so we can improve our own efficiency. On the other hand we extend this facility to others, and by doing so we hope that the effect is beneficial to all concerned.

I am very conscious of the fact that this attempt to present some of the progress made by Ford in the past 25 years has done no more than skim the surface.

We have grown and are still growing, and if the experience which we have gained in the process can be of help to others, we are always happy to pass on the results of that experience.

The President at Peterborough

The President of the Institution, Sir Walter Puckey, took the chair at the recent successful meeting of the Peterborough Section, when Mr. E. C. Gordon England, M.I.Prod.E., gave an address on "Valid Incentives in Industry". Mr. England's audience included several prominent local industrialists and Institution members.

The photograph below shows Sir Walter Puckey chatting to Mr. England and some of the well-known personalities who were present. From the left: Mr. G. Hutchinson (Section Committee); Mr. A. P. Peat (Section Committee); Mr. W. Peck (Section Committee); Sir Walter Puckey; Mr. W. G. Wright (Section Committee); Mr. Gordon England; Mr. J. W. Ramsden (Chairman, Peterborough Section of the I.C.W.A.); Mr. W. J. Ford (Chairman of the Norwich Section of the Institution); Mr. H. F. Adams (Chairman, Peterborough Section); Mr. C. D. Davies (Hon. Secretary, Peterborough Section of the I.C.W.A.); and Mr. W. Ladds, A.M.I.Prod.E.

"Peterborough Citizen and Advertiser"

Study Courses for Industrial Executives

The Institute of Engineering Production states that the series of executive courses in productivity study, which commenced in July, 1953, is still continuing. The programme until July, 1955, is as follows :-

April 18th/19th
"Production Planning and Control."

May 2nd/13th
"Work Study Applied to Secure Process and Product Movement."
May 16th/27th
"The Use of Operational Research in Increasing Productivity."
June 6th/17th
Summer Course on "Work Study with particular reference to Industrial Training Methods".
June 20th/July 1st
Summer Course on "Application of Work Study".

Applications to attend the courses should be sent as soon as possible to The Senior Courses Secretary, The Institute for Engineering Production, "Southfield", 16, Norfolk Road, Edgbaston, Birmingham, 15.

Cripps Chair of Production Engineering, University of Nottingham

The University Council has recently accepted an endowment from Mr. C. T. Cripps, M.B.E., of Northampton, for the establishment of a Chair of Production Engineering, and on the recommendation of the Senate has decided to establish the Chair from the beginning of the Session, 1955/56.

The Professor will be responsible for the organisation of the Department of Production Engineering, and will be expected to take part in the teaching of the students, to undertake research work, and to encourage research among members of the staff and suitably qualified students. He will also be required to give lectures of a character likely to appeal to interested members of the public.

It is intended that the Department should cover the technological side of production, including plant location and layout, machines, tools processes (the study of industrial operations from the engineering point of view), measurement and cost analysis, application of statistical methods in the control of operations, and work study.

The University has agreed that there should be a three-year post-intermediate degree course leading to a B.Sc. degree with Honours in Production Engineering, and the syllabus for the course has been approved in principle by the Senate. It will, however, be the prerogative of the Professor of Production Engineering to make suggestions to the University regarding this course.

The subjects studied lie mainly in the Departments of Production Engineering, Mechanical Engineering and Industrial Economics. The students taking this course, however, will be the responsibility of the Professor of Production Engineering, who will also be responsible for courses in Production Engineering which may be open to undergraduates studying other branches of engineering, and possibly Pure Science.

In the first instance, it is intended to limit the number of students admitted to the Honours Degree in Production Engineering to six per year, and all candidates will be required to have completed one year of approved training in industry before entering the University. It is hoped that the new Professor will take up his appointment on 1st October, 1955. Undergraduates cannot be considered for admission before October, 1956. Unless they have fulfilled the condition of one year's practical experience, they cannot be admitted before October, 1957 and, as the course is drafted at present, will not receive instruction in the Department until 1959. In the intervening period, the Professor will be expected to make the necessary contacts with industry, to enable the organisation of the pre-entry year in industry (similar schemes are already in operation with regard to Mechanical and Civil Engineering, although in this case it is not compulsory), to develop research activity in his field of study, to organise courses for students from other Departments who may require instruction in Production Engineering, to arrange courses for senior members of industry and to organise and develop the necessary laboratories.

The present salary attaching to the post is £2,150, with child allowances. Intending candidates for the appointment should make application to the Registrar, The University, Nottingham, for full details.

NEW BUILDING FUND APPEAL

Since the publication of the last list, donations have been received from the following subscribers. (The list was compiled for press on 11th March, 1955).

Australia
Melbourne Section:
H. A. Cotton, M.I.Prod.E.
R. C. Judge, A.M.I.Prod.E.
C. M. Kennedy, A.M.I.Prod.E.

W. L. Lober, Grad.I.Prod.E.
M. Shaw, A.M.I.Prod.E.

J. M. Brice, A.M.I.Prod.E.
J. A. Bryant, A.M.I.Prod.E.
B.S.A. Ltd.

E. A. Crisp, Grad.I.Prod.E.
N. W. Grice, A.M.I.Prod.E.
D. E. Harrison, Grad.I.Prod.E.
H. T. A. Hayes, A.M.I.Prod.E.
J. Merkine, A.M.I.Prod.E.
T. Roberts, A.M.I.Prod.E.

Mr. E. H. Y. Burden, Member, Director of Machine Tools (India) Limited, will be arriving in England about the middle of May for a period of leave coupled with business, and expects to remain for four or five months.

Mr. S. J. Harley, Member, Chairman and Managing Director of Coventry Gauge and Tool Co. Ltd., has been elected President of the Coventry and District Engineering Employers' Association. Mr. Harley serves on the Institution's Council as Additional Representative for the Midlands Region.

Mr. T. F. Ring, Member, General Manager and Director of E. G. Bishop Pty. Limited, Engineers, of Sydney, Australia, will be visiting England, where he is due to arrive towards the end of April, for the purpose of seeing the latest developments in machine tools and processes. His London address is c/o Bank of New South Wales, Berkeley Square, W.1.

Bassano

The Rt. Hon. Lord Sempill, A.F.C., Hon. Member, is one of three internationally-known financiers and industrialists who have been named as comprising the Economic Advisory Board of Manitoba. Lord Sempill is, of course, well-known to members as a Past President of the Institution, and for the very active part he takes in Institution affairs.

Mr. C. A. E. Vince, Member, has taken up an appointment with the Plessey Company, Limited, as General Manager of their Aircraft Electrical Group's activities at Swindon.

Mr. J. M. Brice, Associate Member, formerly Sales Manager of Rockwell Machine Tool Company, has now been appointed Technical and Commercial Manager. Mr. Brice is Acting Chairman of the Institution's Editorial Committee and also serves on the Papers Committee and the National Conference Organising Committee.

Mr. E. Fedder, Associate Member, has recently been appointed Assistant to the Production Manager of Dowty Hydraulic Units Limited, at Ashchurch, near Tewkesbury.

Mr. C. H. Fraser, Associate Member, has relinquished his position as Assistant General Manager to Ayrshire Dockyard Co. Ltd., to take over as General Manager of their subsidiary company, Metal Trim Limited.

Mr. R. Gore, Associate Member, has been appointed General Manager—Engineering Division, at Sheepbridge Equipment Limited, Chesterfield. He was formerly General Works Manager.

Mr. P. Griggs, Associate Member, has relinquished his appointment with Rolls-Royce, Limited, and has now joined the consulting staff of Personnel Administration Limited, London.

Mr. R. W. Hillyer, Associate Member, has relinquished his position with Rolls-Royce, Limited, East Kilbride, and has now taken up an appointment as Assistant to General Manager with D. Napier & Son, Acton.

Mr. J. Jones, Associate Member, has taken up a position with The Plessey Company at Swindon as Methods Engineer.

Mr. H. Moore, Associate Member, has recently been appointed to the position of Chief Process Planning Engineer with his present Company, the National Gas and Oil Engine Co. Ltd., Ashton-under-Lyne.

Mr. R. R. Rogers, Associate Member, is now Stamping Manager of Brass Pressings (London) Ltd., of Cricklewood, an associate company of Non-Ferrous Die-Castings.

Mr. J. H. Wilkinson, Associate Member, who joined the firm of A. A. Jones & Shipman Ltd., Leicester, in 1928 as a designer of special machine tools, has recently resigned from the position of Chief Designer with this Company to take up a similar position with W. E. Sykes Limited, Staines, Middlesex.

Mr. John Chambers, Graduate, has relinquished his position with Simplex Electric Co. Ltd., of Blythe Bridge, and taken up an appointment as a Work Study Engineer at Guest Keen and Nettlefolds, Birmingham.

Mr. David G. Davies, Graduate, has been appointed Assistant Lecturer Grade B, at The Chester College of Further Education, to teach Mechanical and Production subjects.

Mr. R. S. Eames, Graduate, has resigned his position with S. Smith & Sons (M.A.) and taken up an appointment as a Planning Engineer in the Production Engineering Department of Hoover Limited, Perivale.

Mr. W. Elliott, Graduate, has taken up a position as Senior Draughtsman in charge of the Drawing Office at the Royal Ordnance Factory, Radway Green.

Mr. G. F. Lloyd, Graduate, has now joined William Gardiner & Sons (Gloucester) Limited, as Works Manager.

Mr. A. Mukhurji, Graduate, has been appointed an Assistant Designer of Hindustan Steel Limited, New Delhi, India.

Mr. H. Powell, Graduate, has been appointed Sales Engineer representing British Timken Limited, in the West Midland area.

Mr. A. M. Pritchard, Graduate, has relinquished his post as Assistant Lecturer at West Bromwich Technical College, and is now Assistant Production Engineer at Blackstone & Company, Stamford, Lincs.

Mr. J. Saunders, Graduate, has relinquished his position with A. E. C. Limited, of Southall, in order to take up the appointment of Design Engineer in the Central Research Department of the Morgan Crucible Co. Ltd., London.

PLEASE NOTE

When forwarding particulars of changes of appointment for publication in the Journal, members are particularly asked to supply the information in typewritten form or, if this is not possible, to make sure that all names are written in block letters. This will be of great assistance in ensuring that the information published is accurate.

JOURNAL BINDERS

The Institution is now able to supply the larger size of binder for loose copies of the Journal. Each binder will take twelve Journals.

Binders may be ordered from Head Office, price 10/- each, post free.

Hazleton Memorial Library

REVIEWS & ABSTRACTS

"Stores Accounts and Stores Control" by J. H. Burton. *5th edition. London, Pitman,* 1953. 293 *pages. Diagrams.* 15/-.

It is obvious that Mr. Burton is a sound exponent of his subject and his sectionalised layout of systems, making the whole into a work of easy reference, must be applauded. However, there is no doubt that if the examples of forms had been placed closer to their descriptive text, Mr. Burton's points would have been easier to follow.

The Author emphasises the necessary status and qualifications of a storekeeper, a point only slowly being appreciated in the average firm; one wonders how much money is thrown away annually by the "retirement" into the Stores Department of an otherwise good tradesman of long service.

Another point specifically mentioned is the keeping of the Stores Ledger in the Cost Office, a change that many firms, large and small, would probably find advantageous. Mr. Burton also comments on the apportioning of overheads and the pricing of old stock at its actual cost before any new stock is taken into consideration. This may seem obvious to the reader, but how accurately or honestly is it done in actual practice? J.A.F.

"Symposium on Fatigue": (Papers to the Ergonomics Research Society), by W. F. Floyd and A. T. Welford. *London, H. K. Lewis & Co. Ltd.,* 1953. 196 *pages. Illustrated. Diagrams.* £1. 4. 0.

That fatigue is a complex phenomena is unquestioned and an attempt has been made in this book to bring forward the viewpoints of anatomists, physiologists, engineers and others. A selection of the Papers presented at the Ergonomics Research Society Symposium on Fatigue in 1952, representing these viewpoints, is given.

The production engineer has for a long while been seeking guides to indicate the extent of the loss in output due to fatigue either to the factors or the conditions which cause it. In the latter respect, the effect of temperature is well considered under factory environments. A further interesting point considered is that the "level of lighting has little effect upon an individual once it reaches a level required for discriminating details of the task".

A somewhat new thought on fatigue is that with good organisation and industrial administration the effects of fatigue are reduced. This can also be linked with a further point expressed that incentives and motivation also have an affect. These are obviously important factors which are often not considered.

Many of the experiments on fatigue referred to in the Papers are not carried out under factory conditions, the muscles being taken to a state of complete exhaustion. It is difficult to see from the results of the tests how the information can be of immediate use on the shop floor when, in the vast majority of cases, operators do not approach exhaustion and environment is known to have an effect upon fatigue.

It is apparent from the Papers presented in this book that much new work is being done in the field of industrial fatigue but mostly on the laboratory level. It is to be hoped that this work will be related to practical working conditions on the shop floor in a form that the production engineer can use. G.R.B.

" Principles of Mass and Flow Production " by Frank G. Woollard. *London, Iliffe & Sons Ltd., for " Mechanical Handling ",* 1954. 195 *pages. Illustrated. Diagrams.* £1. 5. 0.

This book reviews the modern trend of the engineering industry to produce in mass, and, where possible, on flow line principles. It should be of the greatest interest to all those engaged actively in production for consumption, and to those observers of the economics of industry in general.

In his introductory chapters, the Author defines mass and flow production, and traces the history of these methods, from an early example of the mass production of ship's blocks in the 19th century, to the automatic transfer machines of modern flow production. He then shows the wide range of application of flow production, and that the system can often be used where the circumstances, at first sight, appear to be prohibitive. In a general survey of the subject, the Author sets down eighteen principles for successful manufacture by mass and flow methods. These principles provide the headings for the subsequent detailed discussion.

The discussion takes the reader through the phases of flow production from market research to final assembly of the end product. Considerable detail has been provided in the chapters on transfer machines and automation, and the automatic transfer machine. The flexibility possible with these highly specialised machines, by using standard work heads and unit power packs, is illustrated.

Flow production is carried to its logical conclusion by consideration of the fully automatic factory, taking the A. O. Smith Corporation's plant for manufacture of car frames in the U.S.A. as one near example. The subject of full automatisation is treated from the practical standpoint and the Author answers some eight hypothetical questions on this technique, e.g., its social impact, initial costs, the operating difficulties, etc. Not the least of these difficulties is maintenance of equipment, and the Author stresses the need for an adequate staff employed on preventative maintenance. Indeed, throughout the latter chapters, maintenance by anticipation and not by default is stressed as a key-point to successful flow production.

In his final chapters, the Author reviews the human relations involved in this production technique, in particular, the complaints alleged on behalf of the consumer, e.g. alleged shoddiness of end product; and the effect felt by the workers, e.g., frustration and monotony.

Throughout the book the Author succeeds admirably in holding the reader's attention by his logical presentation of the material, and by his apt choice of practical examples and illustrations. Mr. Woollard has chosen to write mostly about the automobile industry, with which he has been associated for some thirty years, and in which he pioneered and developed the principles and techniques of flow production in this country.

The principles of mass and flow production covered by the Author apply to both the larger and smaller companies, indeed, they could do much to encourage these smaller firms who sometimes feel they cannot afford to be progressive.

A full and classified list of references is appended.

A.R.N.

" The Grinding of Steel " by Eric N. Simons. *London, Odhams,* 1954. 224 *pages. Illustrated. Diagrams.* £1. 5. 0.

The Author is already known for some useful work in branches of technology not otherwise well covered in a form suitable for the shop man. In this book an attempt has been made to meet a similar need, a comprehensive work giving essential facts about the grinding process; e.g. wheels and wheel selection, depth of cut and work speed, cylindrical grinding, surface grinding, centreless grinding, etc. The processes of honing, lapping, superfinishing, polishing and buffing are also included.

In the main the book is disappointing. Its early chapters on grinding fundamentals are inadequate since the Author fails to make the point that the variables of wheel speed, work speed, depth of cut and area of contact determine the average thickness of chips removed by individual grits. Since this chip thickness and the mechanical strength of the metal being cut determine the force tending to break the grit from the bond, intelligent wheel selection requires an adequate appreciation of the influence of these variables.

The specially drawn diagrams are mediocre, Figs. 1 - 4 on page 17 being particularly poor since they do not show precisely either actual arcs of contact or the type of wheel applications which give rise to various areas of contact on flat surfaces. In Fig. 3 of page 31 the direction of work rotation is the reverse of normal practice. The majority of such illustrations are too small to be effective and many are extremely vague, i.e. Fig. 16, page 10.

In the chapters on grinding processes, one is conscious of the Author's expressed indebtedness to various well-known manufacturers but generally the exposition is less adequate than in the technical literature available from such sources, centreless grinding being a particularly noticeable example. On thread grinding and gear grinding it is hardly to be expected that a single chapter of a 220 page book can be very comprehensive but to try and cover gear grinding in two pages with only four small diagrams is surely attempting the impossible.

The text, though clearly written, will reveal to readers with first hand experience the Author's limited experience in these fields.

Perhaps it is only fair to add that this book could be of some use to the student, draughtsman or layman trying to broaden his background, and due to its wide range of subject matter, as an occasional reference book. In this latter respect the reader will find the chapters on honing, lapping and superfinishing of some assistance. There remains however ample scope for a more ambitious text book in this rather neglected field of technology.

A.J.L.

" Handbook of Industrial Electroplating " by E. A. Ollard and E. B. Smith. *2nd edition. London, Iliffe & Sons Ltd., for Metal Industry,* 1954. 366 *pages. Illustrated. Diagrams.* £1. 10. 0.

The first edition of this book was published in 1947 and since that time it has been recognised as a practical reference book for the electroplating industry. In this latest edition, which has been revised and brought completely up-to-date, the scope has been enlarged and sections have been added covering water supply and drainage, purification of solutions, safety precautions, and costing systems.

The early sections of the book provide all the information necessary for selecting electrical equipment and the Authors have elaborated on the design and advantage of D.C. generators, also the use and limita-

tions of A.C. rectifiers. All aspects of the electrical installation side are thoroughly covered in sub-sections dealing with such factors as supply cables, meters, insulation requirements, heating of solutions, etc.

In the succeeding sections the Authors give a thorough review of the basic plant required, discussing the relative merits of different types of tanks and tank linings, methods of heating, filtration systems, and the most efficient exhaust equipment. There is also a brief chapter covering the application and advantages of automatic plating plants.

The second half of the volume, after a sub-section on water supply and drainage, deals mainly with solutions formulae. Complete solution and processing details for every type of plating and, in many cases, two or three alternatives are listed. Similar information is given for plating on non-conductive surfaces; also treatment for the more difficult materials such as aluminium and stainless steel. The Authors have devoted several chapters to methods of controlling the solutions and purification systems and other factors that have to be considered in order to ensure good consistent quality.

From the inspection standpoint, the reader will find in the later chapters a review of practically every known method and device that is available for thickness and adhesion testing.

The volume concludes with a glossary of terms and abbreviations used in the metal finishing industry and the Authors have also included many useful tables relating to plating generally.

Many illustrations and diagrams are included and the whole work can be thoroughly recommended as a very useful volume for anyone concerned with production plating. H.L.M.

" Management Education in American Business : General Survey " by Lyndall F. Urwick. *New York, American Management Association,* 1954. 136 *pages. Frontispiece. Diagrams.*

A most pertinent Report; and on reading through the contents it is difficult to realise that the writer is in fact referring to the American attitude towards management education and not that of the United Kingdom. Because of this similarity the Report is all the more interesting and is a useful contribution towards appreciating the many points of view on this important subject.

Figures are quoted of the decrease in the number of business leaders who are under 50 years of age compared with twenty-five years ago, and it is suggested that this can be attributed to the failure of business management generally to introduce an orderly and methodical system for the discovery, development, and assignment of executive personnel. The necessity for taking an interest in potential leaders at a much earlier age is stressed, thereby retaining the initial enthusiasm rather than to subdue it, or worse, turn it into disillusionment. Comparisons are made with the training procedure of the American armed services, and the viewpoint is put forward that industry could do a lot worse than emulate many of their principles.

The study was organised by the American Management Association and Lt.-Col. Urwick, of Great Britain, was invited to take charge on the grounds that he was entirely impartial and unconnected with any of the American interests concerned.

The full results of the study are published in four parts, this particular Report being the general summary. G.C.T.

" Induction and Dielectric Heating " by J. Wesley Cable. *N.7, Reinhold Publishing Corp.,* 1954. 576 *pages. Illustrated. Diagrams.* £5. 0. 0.

This book is a comprehensive survey of the whole field of application of both induction and dielectric heating, approximately half of its twenty-five chapters being devoted to each of these subjects. Both sections start with a chapter on theory, followed by a chapter on generators of H.F. energy. The remaining chapters deal with the commercial application of each of the branches. Thus the induction heating section includes chapters on metallurgical applications, brazing and welding, soft soldering, forging and melting and the dielectric section includes chapters on applications in the plastic industry, woodworking industry, foundry, food preparation, drying, etc.

Both sections deal at some length with the mechanisation problems which are met with in the design of handling gear, progressing machines, conveyor systems, etc. The book is illustrated with a large number of photographs of equipment and installations, together with diagrams of inductors and electrode systems, tables of constants and curves of performance. In addition to H.F. induction heating, a brief reference is made to those applications where mains frequency (60 cycles) has been successfully employed.

The book is well produced and clearly written. Its chief merit seems to be that it has collected together practically all the possible and actual uses of these techniques in the whole industrial field. The difficulties to be overcome and the nature of the devices to be used for each of these special applications are clearly set out, so that the reader is soon made to realise what are the essentials of the problem to be solved in each case.

On the other hand, it is not at all easy to gather from the book exactly how far each application has really proved successful in industry and is likely to remain an established process competing favourably with all other methods. At this stage of the art, since it may be said to have come of age, there is not so much interest attaching to possible, rather spectacular, applications as in obtaining a clear, somewhat relentless, assessment of the economic and technical advantages which have been gained by equipments actually installed and working over a number of years. For example, a large number of applications of dielectric heating are given, especially under food processing, which have, admittedly, not proved successful at all, yet not only are these processes described in some detail, but much irrelevant information is given about the nature of the food and even about its method of cultivation. This material is surely unnecessary to the book; its suppression might have enabled it to have been produced more cheaply. It is advertised for sale at £5—a price which, all things considered, is surprisingly high for a work of this class.

R.H.B.

" Some Aspects of Standardisation in the U.S.A. and in Europe " by the Organisation for European Economic Co-operation, Paris—Technical Assistance Mission No. 16. *Paris, the organisation,* 1953. 89 *pages.* 5/6d.

This Report presents the observations of a Mission of European experts on the organisation of standardisation in the U.S.A.

The Mission was struck by the separation between the Government and industrial standards, each one following their own procedures in initiation, preparation and application of even very closely related specifications.

All specifications for Government purchases are initiated and prepared by Government agencies: the Munitions Board, Standards Agency for the Military Specifications and the Federal Supply Board for Civilian Specifications. Although these agencies cooperate with manufacturers to ensure that their standards are practicable, there is no integrated machinery, similar to that obtaining in European countries, to ensure that there is the maximum practical co-ordination of Government and industrial standards and the fullest sharing of the work of standards preparation.

Standardisation in industry (and by industry) suffers, on the whole, from lack of integration. There is the American Standards Association (A.S.A.), nominally the top co-ordinating body; the American Society for

Testing Materials (A.S.T.M.), several professional societies (A.I.E.E., A.S.C.E., A.S.M.E.) and scores of technical and trade associations, each issuing their standards, sometimes through A.S.A., sometimes entirely on their own. The number of standards issued by the A.S.A. is 1,250. The Directory of Commodity Specifications, issued by the Government, lists no less than 35,000 standards produced by individual Government, technical and trade organisations.

Although the Report cautiously stresses that the Mission "does not wish, and does not consider itself competent to recommend specific measures by which the further development of standards work in the United States should take place", the facts speak for themselves and the conclusions are obvious.

The difficulties of the A.S.A. in attaining the full status of an independent national standardising body stem from the American political traditions and the fear of monopolistic practices. Nevertheless, there is a growing understanding of the advantages of the national and international co-ordination which could be secured by a single and authoritative body.

Apart from this main theme of the Report, there are some interesting marginal remarks which are worth mentioning, for example, the speed and effectiveness with which the Commodity Standards Division can carry out its programme of simplification, and the importance of cataloguing work, which in this case means establishing precise means of identification of any commercially available item.

A striking example of simplification is the recent reduction of 1,187 different parts of internal combustion engines of 3 to 4 inches bore to 59 standard parts.

The work of cataloguing, undertaken by the Federal Supply Board, is considered by the United States Government as one of great importance and value. The need for this was emphasised by the fact, that during the dispersal of surplus Government assets after the Second World War it was found that many identical items were stored under different names, and it even transpired that many troublesome shortages during the War had been purely illusory, the much needed items already existing in large quantities, but under different identifications. The Mission was informed that Anglo-Canadian-American agreement was being sought on this system of standard commodity identification.

"It is well known to the Mission"—states the Report—"that similar catalogues have been prepared for industrial firms both in the United States and Europe, and that specialists in this class of work have arisen. It raises the question whether sooner or later a new problem in national and international standardisation may not arise if a multiplicity of cataloguing systems develops".

Part 2 of the Report gives a brief survey of standardisation in various American industries and the appendix outlines the structure of standardising bodies in Western European countries.

E.G.B.

"Metals Engineering Design" edited by Oscar J. Horger. *London, McGraw-Hill,* 1953. 405 *pages. Illustrated. Diagrams.* £3. 12. 6. (A.S.M.E. Handbook).

The essential function of a designer is so to plan, contrive or specify results that they can be realised in practice. The engineering designer, for example, has to foresee by what means he can bring suitable materials into particular forms and constructions and thus achieve, or serve, useful purposes. It therefore is necessary for him to possess the requisite knowledge, scientific and empirical, gained by study and experience, of the theories relating to structures and the properties of materials. Thus, a handbook dealing with the essential properties which need to be evaluated by the design engineer when selecting the appropriate material, is invaluable. This book, edited by Oscar J. Horger, and written by many authors well-known in the field of American engineering, comprehends and informs in direct terms on a great many, if not all, aspects of modern metals knowledge. It is printed in clear but small type on large pages, 9-7/8 in. × 7-1/8 in. The six parts cover the selection of materials, mechanical properties of metals, mechanical factors influencing corrosion, metallurgical factors, considerations and procedures for design.

Of course, the basis of engineering design is the determination of stress and strength in relation to the duty and durability required, and with these are the requirements of size, form and finish and the offsetting of detrimental effects as, for example, by production processes. Difficulties to be met are the necessity to make choices of metals dependent on availability, and the most economic means of forming and finishing. That these are surmountable without detriment to satisfactory results, is due not only to the very large ranges of metals and alloys available, but also to the designer's knowledge combined with the works of reference available to him. For any particular design the essential physical properties required must be evaluated by the choice of materials. This entails sufficient foresight to consider the effects of environment, types of loading including impacts and frequency, cold working, heat treatment, wear, corrosion, flaws and other faults, and production methods, etc.

With its great wealth of information, this book provides for all this. It relates to modern refinements which affect design practices, reshapes older empirical data with material obtained by analytical methods. Shape and geometry are shown to be of greater significance than any other factor for ensuring the best satisfaction from products. It tells much more than any one can store for his fund of knowledge. Indeed, it is written by many authors, each one being a leader in his own sphere, and in that fact lies its great value, since each separately written treatise is an indispensable guide for design. No longer is it enough for dynamic conditions to assess values from static conditions. The occurrence of fatigue in metals requires careful attention to the elimination of stress raisers, or to the proper distribution of stress where high concentrations would lead to sudden disastrous failures. Necessary knowledge includes the effects of grain size and flow, machining, drilling, and slotting, surface finish, and all the other aspects which cannot be provided for by mere dimensions which in static conditions would be ample. It is here in one book for the use of design and research engineers, and for advanced students.

R.C.R.

"Cold Working of Metals." American Society of Metals, Cleveland, Ohio. *Cleveland, The Society,* 1953. 364 *pages. Illustrated. Diagrams.* £2. 2. 6.

Proceedings at a Convention or Congress sometimes sound very good, being full of high-mindedness and lofty sentiment, but when analysed do not have much real value. Sometimes the speakers and audience get down to earth and some good comes of it. To get, as in "The Cold Working of Metals", a really first-class scientific treatise, is most unusual. It is justly termed a Seminar and well worth publishing in book form.

This Seminar was held during the 13th National Metal Congress and Exposition at Philadelphia during October 1948 and was sponsored by the American Society for Metals. There are 17 papers and the subjects dealt with are general deformation, cold working, plastic deformation, creep, fatigue and work hardening. The Papers investigate these subjects very thoroughly from a metallurgist's point of view.

In every case the particular subject was discussed in a very clear manner, and the qualifications of the authors, the references quoted and the sound, logical arguments expounded left no doubt as to the value of the works.

This book is a well written and well presented scientific work which could be of great value to the metallurgist specialising in the "cold working of metals".

R.E.M.

" Scientific Research and Development in American industry: a study of manpower and costs ".

Department of Labor—Bureau of Labor Statistics United States of America. Washington, Government Printing Office, (1953) 106 *pages. Diagrams. Charts.* 50c.

This Report covers an investigation, made in mid-1952, of American industry to determine the type of scientific research carried out by American industry and the method by which it was governed. Nearly 2,000 concerns were contacted employing a total of about 6,500,000 people. The Report describes the detailed manner in which this investigation was carried out and is a model of this type of investigation, normally so irksome to the " questionee ".

The Report is extremely enlightening in as much as costs are related to the unit research worker. The average cost per research engineer or scientist in 1951, for example, was apparently 21,900 dollars. It should be appreciated, however, that by definition this only includes people of degree standard or above who are normally supported by many other workers. Figures vary largely according to the type of industry but, compared with British practice, it would appear that much more emphasis is given to the status of the research worker and his salary.

To the practising production engineer the Report is probably only of general interest, but to the executive concerned with the relative expenditure on research, production, commercialisation and the like, the Report is an illuminating experience of American practice.

P.S.

ABSTRACT

" Statistics for the Cost Accountant " by J. A. Reece. *London, Institute of Cost and Works Accountants,* 1954. 40 *pages. Diagrams.* 5/-. (Occasional Paper No. 1.)

This booklet outlines the subject of statistics showing their application to typical business problems which are also of interest to production engineers. It gives a brief and clear treatment of the subject and thereby eliminates padding.

The Author, by examples, shows the meaning of statistics and then again by use of examples, outlines statistical method. The uses of published statistics are indicated, together with the pitfalls which might be encountered by the unwary. Statistical theory and its limitations is then more fully explained.

A chapter on time series covers adequately the type of statistical problem in which data either in value or quantities fall in successive periods of time. Adjustments to ensure the consistency of the units used are dealt with. Trends, seasonal variations, and published statistics, which come under the heading of time series, are illustrated graphically.

A resumé of the part of statistics which is encountered by all in everyday activities, namely average and dispersion, is adequately treated in the next chapter. A short chapter follows dealing with index numbers and their uses.

In order that a decision to expand or contract output, or to change the pattern of activities, may be made, it is necessary to estimate the relevant market factors and use this together with cost accountancy. Market research is dealt with in the chapter on economic statistics, which then goes on to mention briefly statistical costing, the use of scatter diagrams and curve fitting.

Control charts and their uses are explained in the final chapter.

An appendix gives in greater detail the derivation of some typical statistical problems previously referred to in the Paper.

ADDITIONS

621.778 WIRE DRAWING AND PROCESSING

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AUTOMATION

A Select Bibliography

(This is supplementary to the Bibliography published in the February, 1955, issue of the Journal. For the selection of items for inclusion and for the notes, the Institution is indebted to Mr. Frank G. Woollard, M.B.E., M.I.Prod.E.)

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75: 207-210, March, 1953. Waddell, H. L. Progress in automatic production. **"An examination into the mechanical, managerial and socio-economic requirements of ultimate automation. That is the fully automatic facory."**

MECHANICAL HANDLING

41: 639-641, November, 1954. Davis, L. G. Turbo-compound engines produced by automation. **"Near automated assembly line at Wright Aeronautical Division of the Curtiss-Wright Corporation."**

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33: 147-148, August, 1954. Schmidt, A. O. Tool problems in automation. **"A short note on tool life and the economic advantage of not pressing cutting tools to the utmost."**

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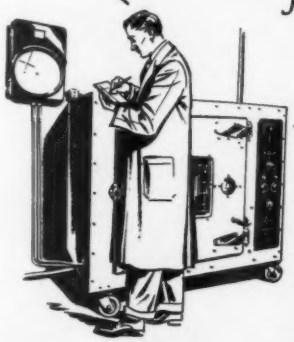
Without this quality, few research projects would come to fruition and the world might yet be awaiting the ideal die casting alloy MAZAK.



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Wimet CLAMPTIP TOOLS offer even longer life from carbide tools

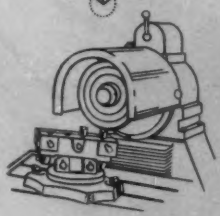
The Wimet range of Clamptip tools offers users the benefits of improved tool performance, infinitely longer carbide life, and a variety of tooling possibilities.
These tools may be used in any combination one with another or incorporated with standard tools in a set-up.

STRESS-FREE SOLID INSERTS

Tool performance is improved since the solid carbide inserts are secured entirely by mechanical means and thus remain free from the stresses usually inherent in brazed tools.

MULTIPLE CUTTING POINTS

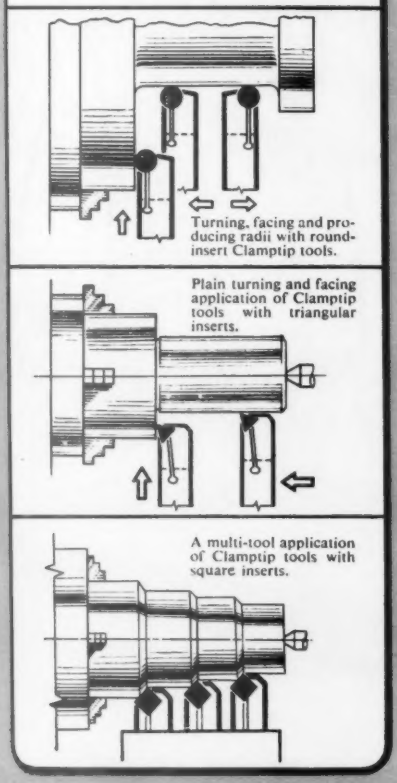
When cutting edges become dulled, the insert can be repositioned in its holder. Only when all edges have been so used is it necessary to remove for resharpening.



SIMPLIFIED RESERVICING AND UNDISTURBED TOOL SETTINGS

In multi-tool set-ups the use of Clamptip tools enables tool settings to remain undisturbed when carbide inserts require removal for reservicing. At the end of the long carbide life of the tool, the insert is replaced with another of standard size (alternatively, the remaining unused carbide may be brazed to a steel insert when the fullest possible service may then be obtained from the Wimet).

Typical applications



Turning, facing and producing radii with round-insert Clamptip tools.

Plain turning and facing application of Clamptip tools with triangular inserts.

A multi-tool application of Clamptip tools with square inserts.

Made in Three Types

Wimet Clamptip Tools are made with round, square, or triangular inserts in a range of sizes of each type. Inserts are available in grades of Wimet recommended for roughing or finishing cuts on either cast iron and non-ferrous materials or steels.

Write to-day for your copy of the Wimet Clamptip Tools leaflet. It contains full details of all types, sizes, and grades of Wimet inserts available.

WICKMAN *of* COVENTRY

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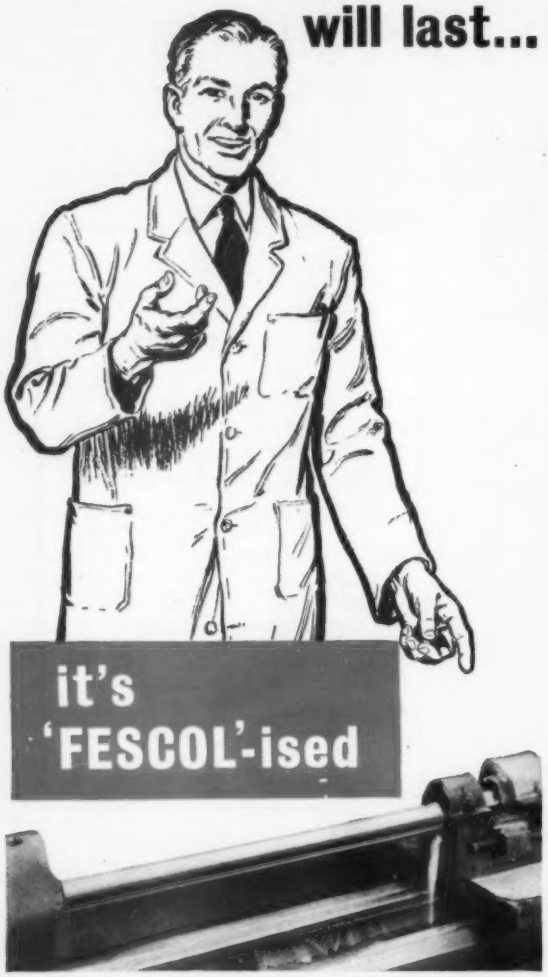
348ST.

This boring bar will last...



Boring bar 'Fescol'-ised in Chromium.
Photograph by courtesy of Messrs. Accles & Pollock Ltd.

The FESCOL process of electro-chemical deposition gives machine tool components a hard, smooth surface which resists abrasion and corrosion, and considerably lengthens the life of moving parts. Worn components and new machinery alike can be treated in this way.

As no heat is involved there is no damage to the basic metal. The FESCOL process is suitable for parts both large and small.

Executives are invited to write for list IP2, which fully describes applications on many types of machine tools.

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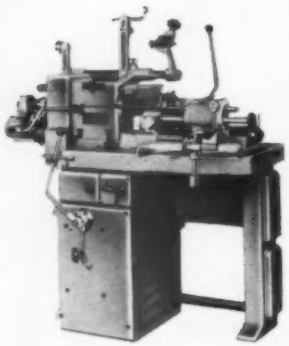
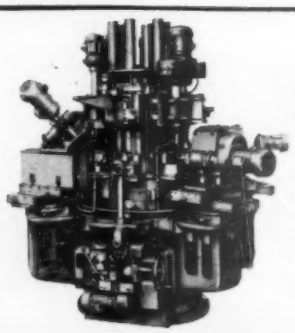


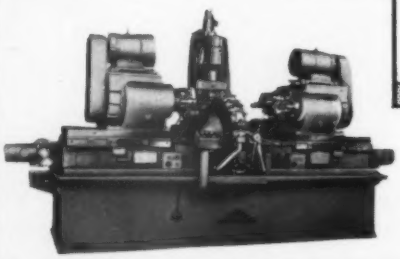
Capstan Lathe Models RH18 and RH25 (Hahn & Kolb design)

Max. Bar. Dia.	RH18	¾″	RH25	1″
Max. Dia. of chuck work (collet chucking)	RH18	2⅜″	RH25	2⅜″
No. of tool holder holes	RH18	6	RH25	6
Dia. of tool holder holes	RH18	⅜″	RH25	⅜″



EPPINGER High Production Multi-Operation Automatic Model ESA2

Cast, stamped, drawn and turned ferrous and non-ferrous metal components, machined with maximum economy. Drilling, boring, countersinking, reaming, milling, oblong hole milling, mortising, threading, tapping, etc., at one setting.



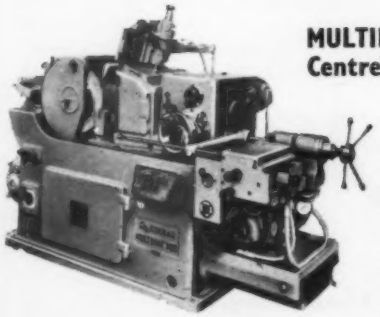
HONSBERG Electro-Mechanically controlled Transfer Production Unit Machines

Efficient batch production of precision work. The illustration shows a typical set-up, but a great variety of operations on components of various shapes and sizes may be arranged.

UNIVERSAL Hydraulic Lapping Machines Model LHD (Hahn & Kolb design)

For cylindrical and flat work by cast iron and abrasive wheels. Flat components lapped on both sides or one side only as required.

Max. Dia. of lapping wheel LHDO 16″ LHDIA 33″
Max. length of work piece LHDO 4″ LHDIA 10″



MULTIMAT Centreless Grinders

Through and in-feed grinding of plain cylindrical and formed components. Bar grinding attachments for bars up to 10 ft. long.

Models	O	In.	II	III
Max. Dia. of work to be ground abt.	1⅛″	4″	4½″	8″
Min. Dia. of work to be ground abt.	3/32″	5/64″	5/64″	⅛″
Dia. of grinding wheel	12″	16″	20″	24″
Max width of grinding wheel	4¾″	7½″	8″	16″

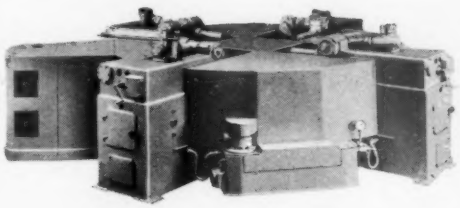
EICKHOFF Tool Grinding & Lapping Machine Model E2

For hard metal alloy tipped turning tools. To change over from grinding wheel, to lapping wheel swivel grinding headstock correspondingly. Special attachments for grinding of clearance angle, chip breaking grooves and radii.

Dia. of diamond grinding wheel 6″
Dia. of diamond lapping wheel 6″
Bore of wheels dia. ½″
Speed of wheels revs. p. min. 2800

SIDNEY JONES

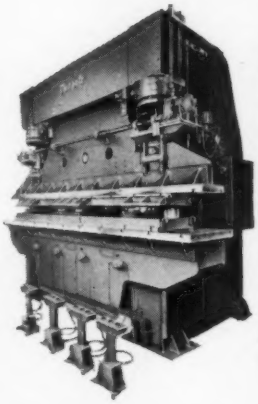
NOW SOLE AGENTS for these machines in the HAHN & KOLB range!



Abrasive Immersion Grinding and Polishing Machine Model TSM3

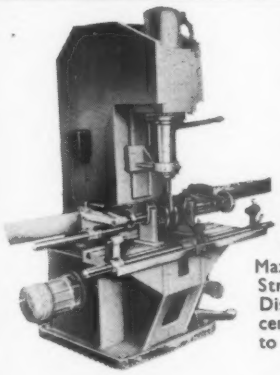
For components up to 16" length or dia. 4 working stations, each including tilting work holder. Automatic operation except for loading and unloading. 4 components, all alike or different size or shape, dealt with at same time. Electric motor up to 50kW drives rotary compound container, variable grinding speed between 45 and 75 feet per second.

Dia. of rotary grinding compound container	120"
Height of rotary grinding compound container	20"



MENGELE Folding Presses with Oil-Hydraulic Control

Smooth operation. Protection from breakage even when die carelessly set. Pressure can be exerted for any length of time. Single-stroke safety device. Presses for any pressure.



Hydraulic Straightening and Assembly Presses Model HPW

Straightens arbors, spindles crankshafts, cam shafts, sectional iron, etc. For all bending and assembly jobs.

Models HPW	15	50	100	150
Max. pressure tons	16.5	55	110	165
Stroke of ram in.	12	14	14	14
Distance from centre of table to body in.	8	8	10	12

UNIVERSAL Marking Machine Model KI

For lettering flat, cylindrical and circular arc work for knurling, and for producing small serrations on flat and cylindrical components. Attachments available for successive numbering, and for lettering gears, discs and rings of any radius.

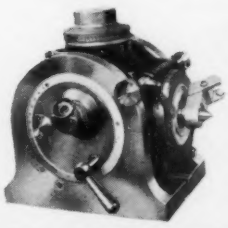
Max. dist. between table and marking tool	8"
Max. radius to be marked	7"
Max. lettering length	6"

LIEBHERR Universal Gear Hobbing Machine

For accurate and high production of spur and helical gears, worm gears, sprockets, etc.

Model	S5	S5-V	S7-V	S9
Gear dia.	23"	32"	71"	118"
Max. Hobbing width (spur gears)	14"	14"	23"	59"
D.P.	4	5	2	1
Dia. Worktable	21"	21"	51"	88"

Automatic Hob Shift—Automatic Cycle.



OPTIGON Optical Dividing Head

Reading accuracy 0.1 minute.
Height of centres 5½".
Morse taper 4.

Write now for full details of these machines in the Hahn & Kolb (Stuttgart) range

SIDNEY G. JONES LTD

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BECAUSE we have equipped and staffed our organisation technically and specifically to deal with **all** *the problems of modern metal cleaning, we are able to provide the right process and the right product to meet any unusual requirement. Consultation with "S.A.C." technicians is the streamlined way of getting the answer which saves you time and cost.*

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SUNBEAM ANTI-CORROSIVES LTD.

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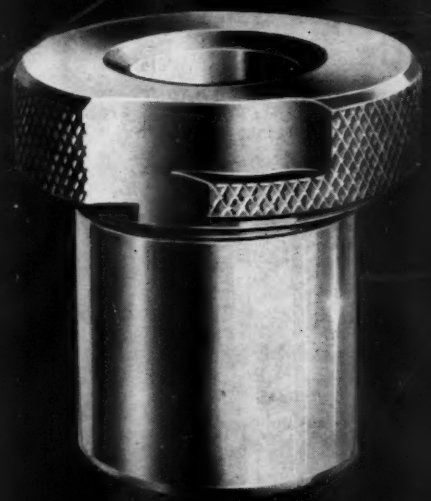

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Cost less to use

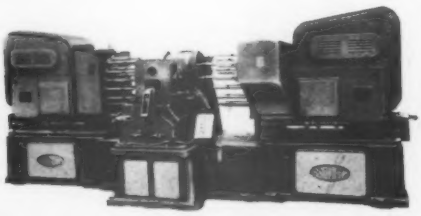
Nitriding makes 'em last!

BRITISH AERO COMPONENTS LTD., MONTAGUE ROAD, WARWICK. TEL. WARWICK 320

Tell us how you want it

ASQUITH Unit Heads, suitably placed around a workpiece, enable a number of multiple drilling operations to be carried out simultaneously. Changes in design can also be catered for without recourse to a complete new machine. Constructed on the most modern lines they uphold the ASQUITH tradition for efficiency and economy.

ASQUITH



UNIT HEADS

WILLIAM ASQUITH LTD., HALIFAX, ENG.

LONDON OFFICE: HALIFAX HOUSE, STRAND, W.C.2

Sales & Service for . . . **DRUMMOND-ASQUITH** *. . . the British Isles*

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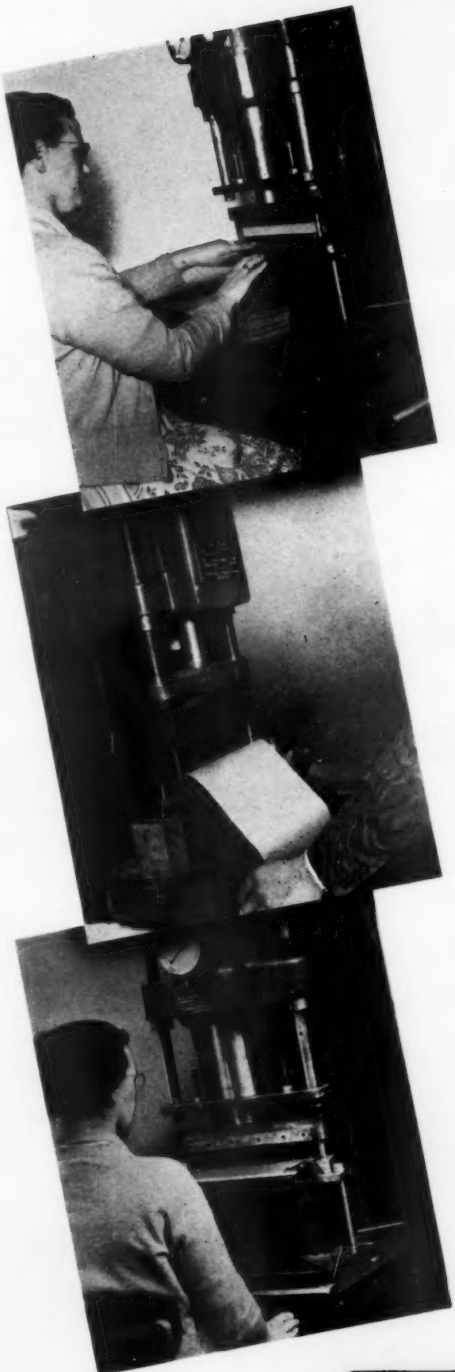
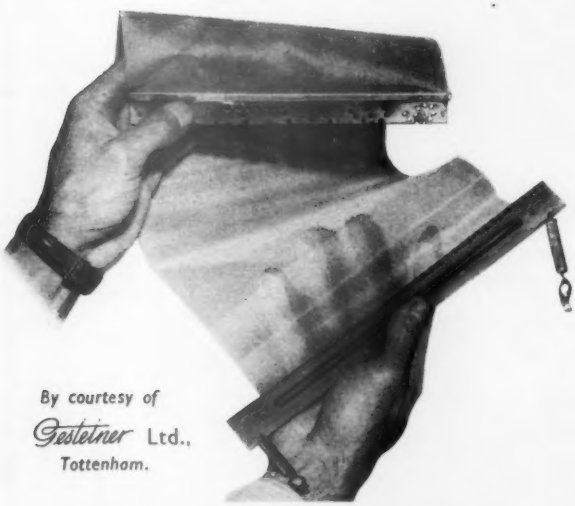
'Phone: Midland 3431 (5 lines) *Also at LONDON: 'Phone Trafalgar 7224 (3 lines) and GLASGOW: 'Phone Central 3411*

Anderson

Another HI-TON *Success Report*



There are few instances which have proved more successful than the installation of HI-TON presses at *Gestetner* Ltd., Tottenham, where these machines are being used for delicate pressing operations on duplicator screens and protectors. Precision assembly, high output and ease of operation are valued features of the installation.



By courtesy of
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MODELS FROM 1 TO 250 TONS

HI-TON HYDRAULIC PRESSES

For Speeding up Production Assembly

FULL PARTICULARS ON REQUEST

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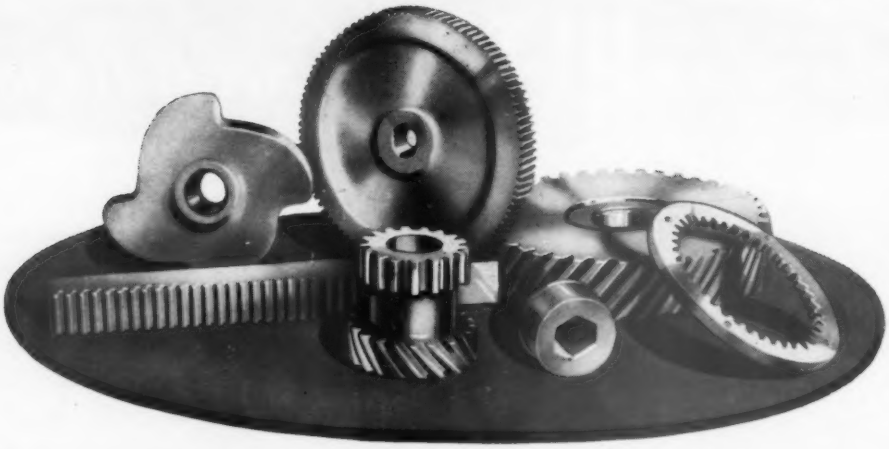
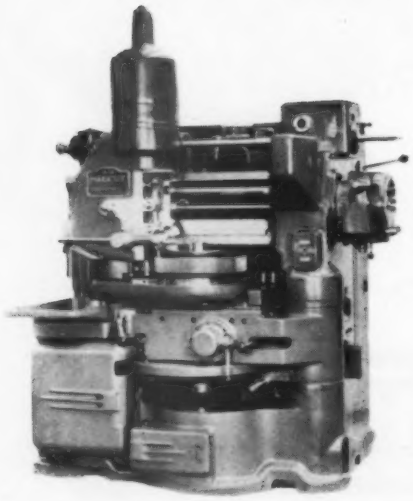


For highest production—



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of course!

MAXICUT Gear Shapers, installed in every high production plant throughout Great Britain, are responsible for the major portion of the nation's output of gears. A MAXICUT ensures high output, accuracy and adaptability.

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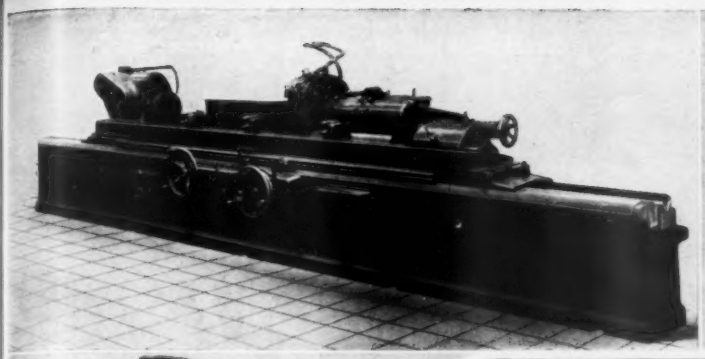
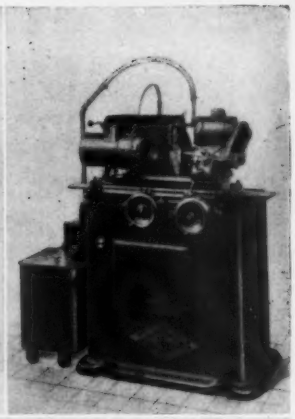
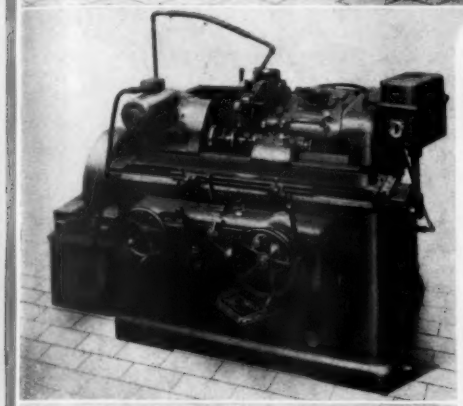


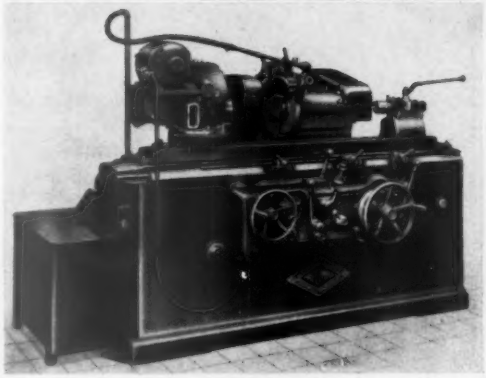




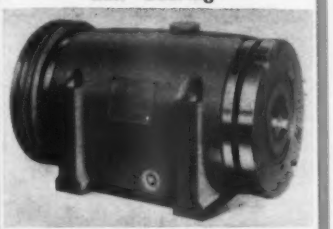
A few types of

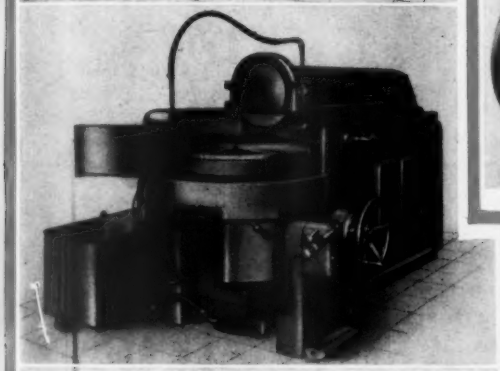
"PRECIMAX"

PRECISION
GRINDING MACHINES
AND
FINE BORERS



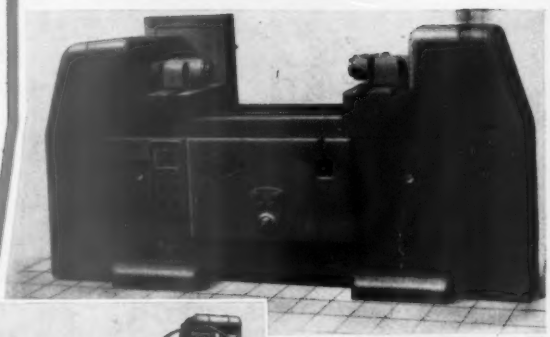
BORING HEADS
Ball Bearing

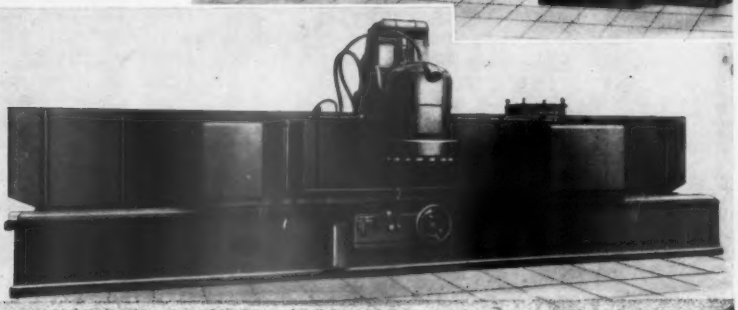




FORM
WHEEL TRUING
ATTACHMENT
Hydraulically
Operated

Plain Bearing





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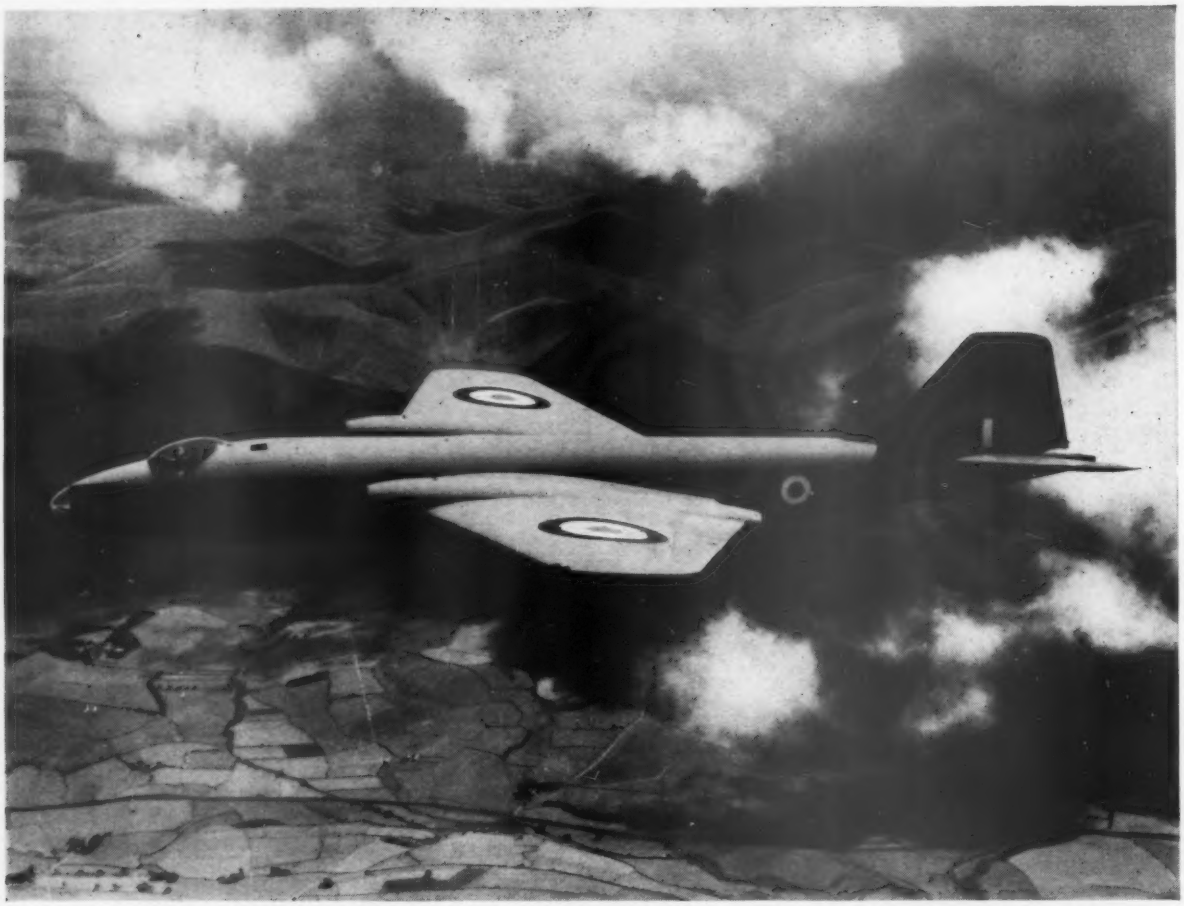
EASTBURN WORKS, CROSS HILLS, nr. KEIGHLEY

Telephone: 3211-3212-3213 Cross Hills Telegrams: "Grinding, Crosshills."

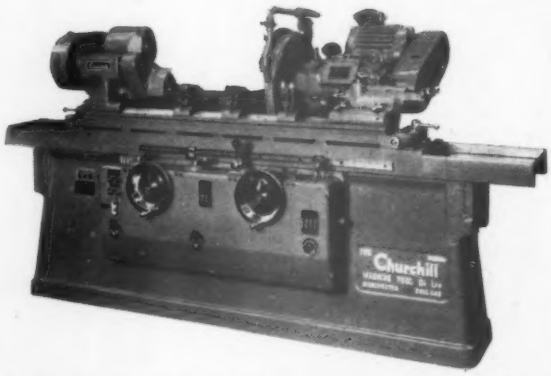


'English Electric' Canberra
(Photograph by permission)

Churchill

By their ability to maintain low limits and fast production rates CHURCHILL Precision Grinders make an important contribution to the outstanding achievements of the British Aircraft Industry.

Illustrated here is the CHURCHILL Model 'BW' 10" × 36" Plain Grinding Machine, which can be supplied as a non-automatic or a fully automatic Plain Grinder.



THE CHURCHILL MACHINE TOOL CO. LTD., BROADHEATH, nr. MANCHESTER

Export Sales Organisation: Associated British Machine Tool Makers Ltd., London, Branches and Agents

Home Selling Agents: Charles Churchill & Co. Ltd., Birmingham and Branches.

PRECISION *plus* PRODUCTION

C641

For Maximum Production

Ward No. 2C CAPSTAN LATHE

SCREWED BUSH

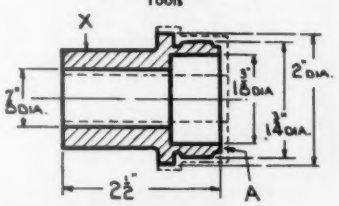
Floor to Floor Time: 1 minute 35 seconds

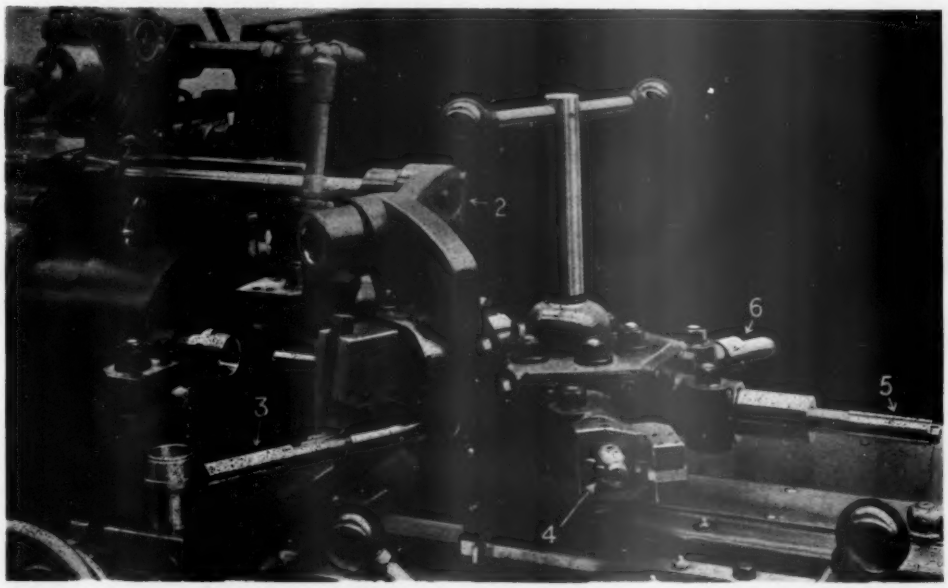
DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
Chuck at X (using Loading Adapter)	1	—	—	—	—
Rough Face End A	—	Front	2041	1000	Hand
Rough Bore $\frac{7}{8}$" and $1\frac{3}{8}$" dias. and Knee Turn $1\frac{3}{4}$" and 2" dias.	2	—	1020	534	216
Finish Bore $\frac{7}{8}$" and $1\frac{3}{8}$" dias.	3	—	2041	735	216
Chamfer Bores and Break Corners	4	—	2041	1070	Hand
Ream $\frac{7}{8}$" dia.	5	—	321	75	Hand
Finish Face End A and Undercut	—	Rear	2041	1070	Hand
Remove (using Unloading Adapter)	6	—	—	—	—

Fitted with "Lang" KL.155 Air-Operated 3-Jaw Chuck

Gun Metal Casting

Tungsten Carbide Cutting Tools





The standard No. 2C Capstan Lathe has a bar capacity of $1\frac{1}{4}$in. with a swing over the bed covers of $13\frac{1}{4}$in. Many new features are incorporated including inbuilt electrical equipment, twelve spindle speeds, both forward and reverse, raised centres giving an increased swing, large capacity swarf tray, bed protected by stainless steel covers, etc.

OUR COMPLETE RANGE INCLUDES CAPSTAN AND TURRET LATHES WITH CAPACITIES UP TO 35 in. SWING OVER BED AND $8\frac{1}{2}$in. DIAM. HOLE THROUGH SPINDLE.

Full details on request

H. W. WARD & CO. LTD

SELLY OAK BIRMINGHAM 29

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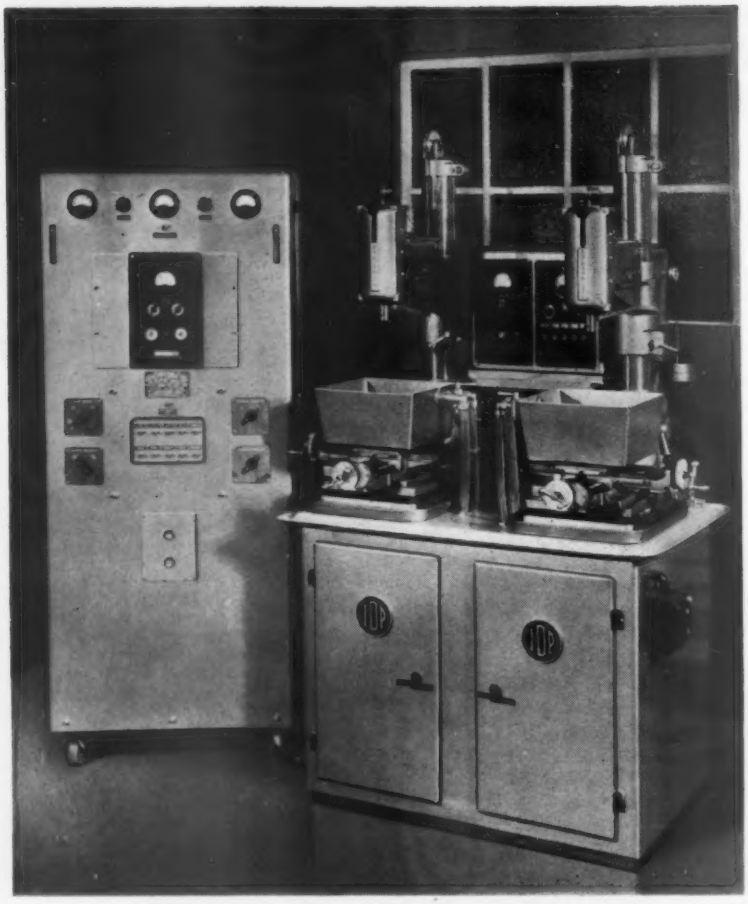
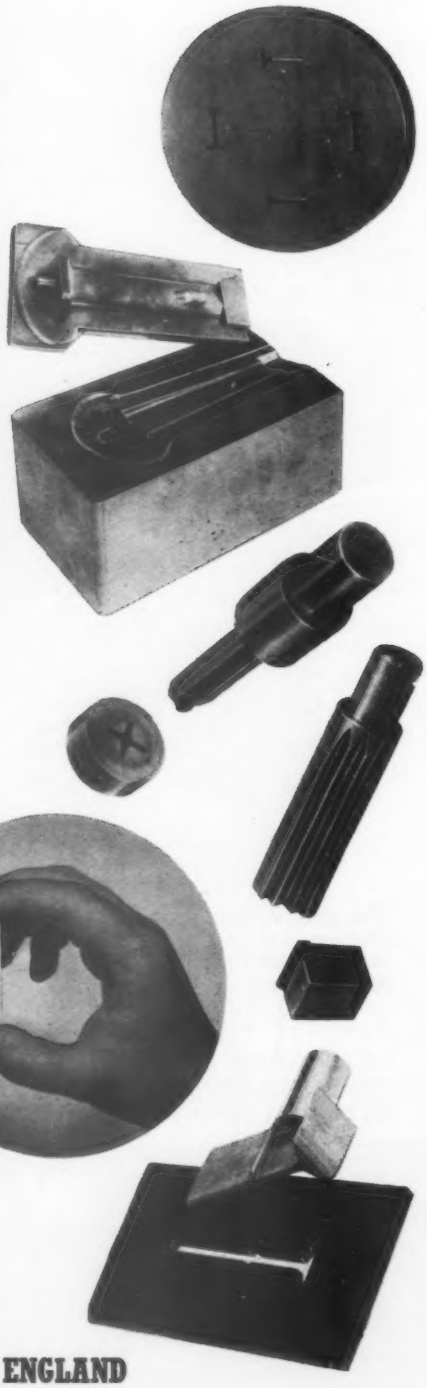
W605



For production of all types of dies and form tools.



The leading manufacturers of spark machining equipment in the world, have pleasure in announcing their latest

SPARCATRON Mk. II Model

With double head.

This addition to the Sparcatron range of machines for spark machining has been produced as the result of requests for an equipment for use with large section electrodes to be operated to very close limits, and can be supplied with two heads as illustrated, or with a single head.

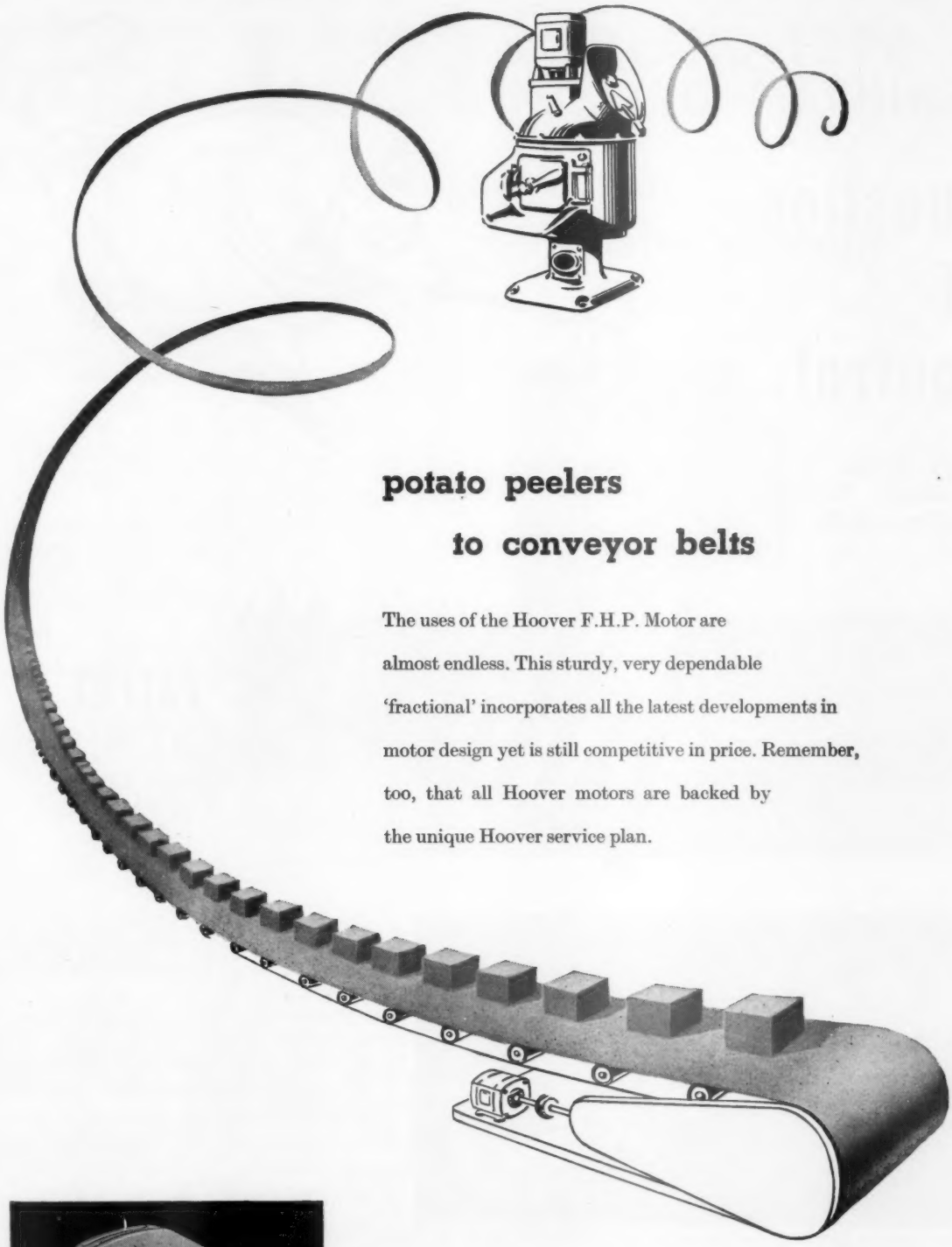
The twin head model can be easily worked by one operator, and the heads operated separately, so that production per man hour is doubled.

A further two or more heads may be used in conjunction with the main control unit in some circumstances.

Manufactured by:

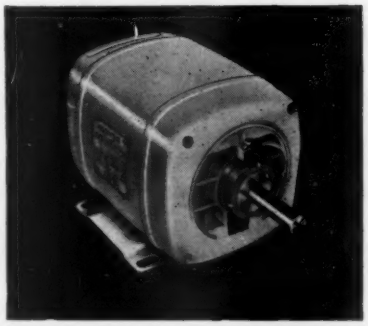
IMPREGNATED DIAMOND PRODUCTS LTD., GLOUCESTER, ENGLAND

TELEPHONE 21164 (3 LINES) TELEGRAMS IMPREG GLOUCESTER



potato peelers
to conveyor belts

The uses of the Hoover F.H.P. Motor are almost endless. This sturdy, very dependable 'fractional' incorporates all the latest developments in motor design yet is still competitive in price. Remember, too, that all Hoover motors are backed by the unique Hoover service plan.



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A question of control...

There's no fear of losing carbon content and consequently hardness, when fabricating or rebuilding tools by the

STAG ATHYWELD PATENT DEPOSIT WELDING PROCESS

Complete metallurgical control is possible, the deposit of almost any type of ferrous metal becoming an integral part of the parent metal.

Athyweld is the perfect method of depositing high-speed steel for cutting edges, in knives and tools of all descriptions, and for repair of broken milling-cutters, gear cutters, etc., at minimum expense.

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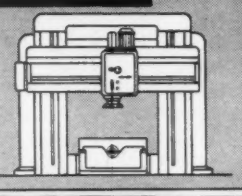
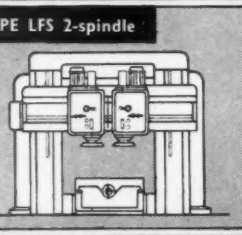
HELLER PLANO-TYPE MILLING MACHINES

for higher output and greater economy

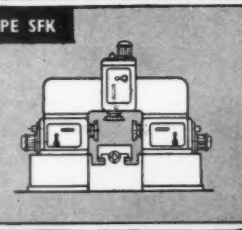
TYPE LFS 1-spindle



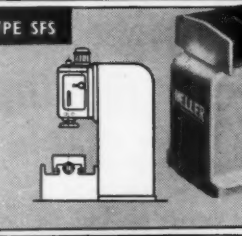
TYPE LFS 2-spindle



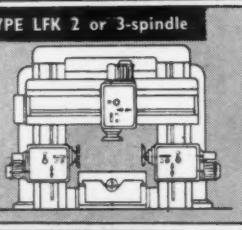
TYPE SFK



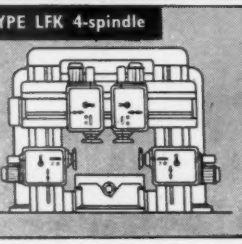
TYPE SFS



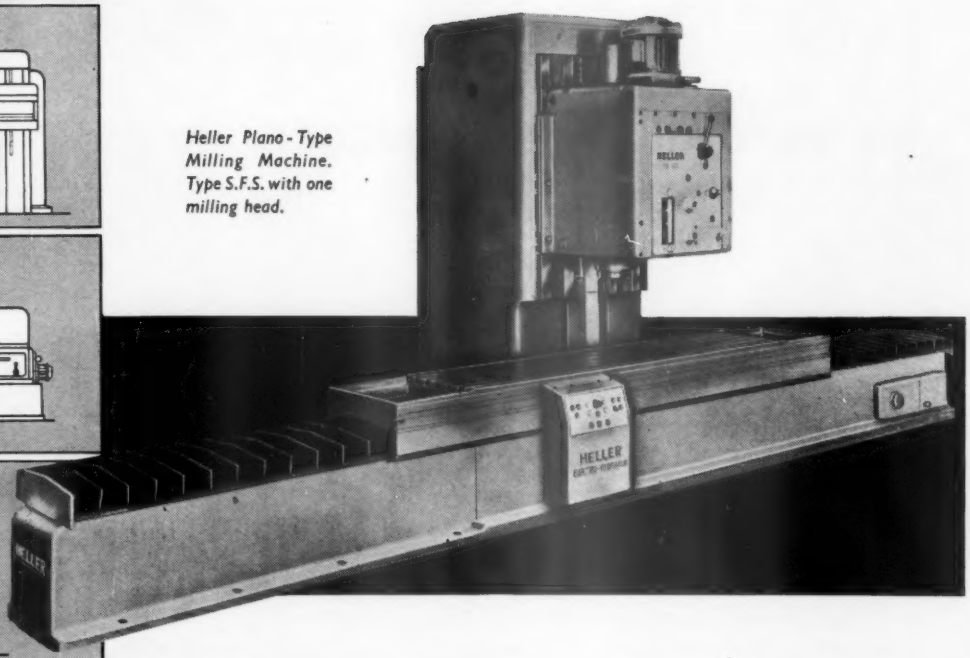
TYPE LFK 2 or 3-spindle



TYPE LFK 4-spindle



Heller Plano-Type Milling Machine. Type S.F.S. with one milling head.



The simultaneous milling of several faces on one workpiece—often in different planes and at different angles—is the answer to the demand for increased output of many complex parts. It obviates re-clamping and re-aligning and in many cases reduces the number of machines required for production.

Heller Plano-type Milling Machines are designed on the unit-assembly system and can be literally 'built around the component'. The major units are the milling heads, tables, feed mechanism, uprights and frames. The selection of units depends entirely on the work required; for example, light milling heads and a large table can be used for bulky workpieces with only small faces to be milled, or alternatively, heavy milling heads can be employed with a small table for heavy milling on small components. The power employed is therefore related to the workpiece and not to machine table size, and milling heads of different sizes can be fitted to the same machine. The economic advantages of this system of construction are therefore extended into actual operating, saving power and floor space.

Some of the most commonly used arrangements are shown opposite. There is a catalogue available which gives full details. Write for a copy now.

WICKMAN LIMITED

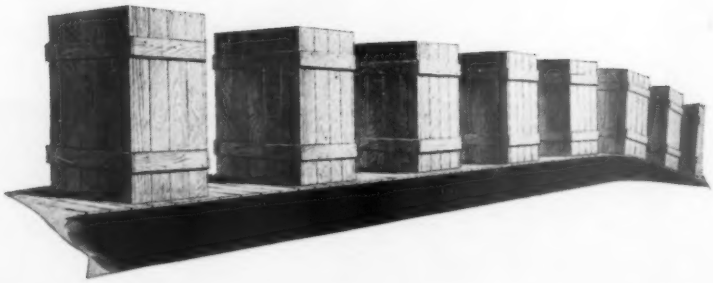
FACTORED MACHINE TOOL DIVISION, FLETCHAMSTEAD HIGHWAY, COVENTRY

Telephone: Coventry 40351

Tungsten carbide for long tool life —that means **Wimet**

355F82

we were all over the place



until we called in KING *(and got things moving)*

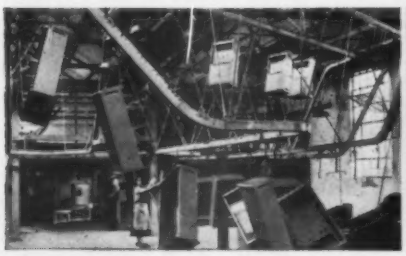
Inefficient, outdated handling methods can play havoc with production figures. They eat up the minutes, the man-hours and the money. More and more production men are becoming aware of the need for modern mechanical handling methods. If you're not happy with your present handling methods, **call in KING and get things moving.** *Our representative will call on you—anywhere in the world.*

***STREAMLINE* YOUR PRODUCTION WITH**

KING REGISTERED TRADE MARK **CONVEYORS • CRANES • PULLEY BLOCKS**

Covered by British and Foreign Patents

A KING P.C.P. LIGHT-TYPE CONVEYOR *carrying heater bodies at Valor Company's Works. For loads up to 200 lbs.*



A KING OVERHEAD TRAVELLING CRANE—*cab controlled—working with precision in a foundry.*

A KING POWER-PULLED HEAVY DUTY CONVEYOR *shown working at the Robbialac factory. For loads up to 1 ton.*

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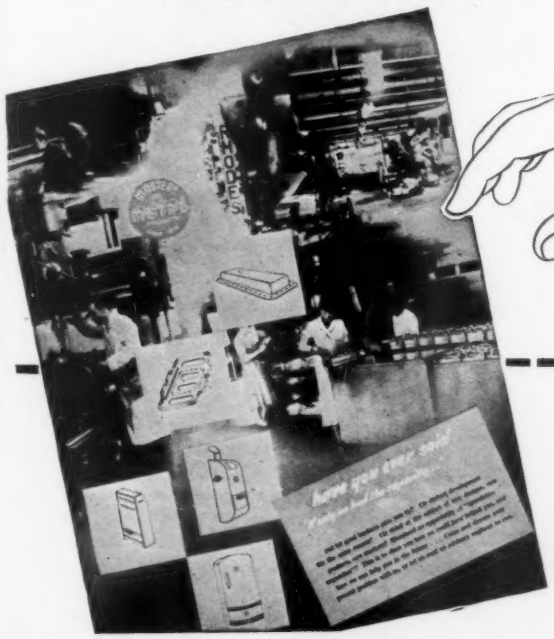
Put our resources alongside your own

When production makes demands that your own capacity cannot conveniently handle and target dates are still to be met, we are available to take the load. By sub-contracting to us high production can be achieved to time without further capital investment. Our facilities include tooling, fabrication, welding, finishing and assembly.



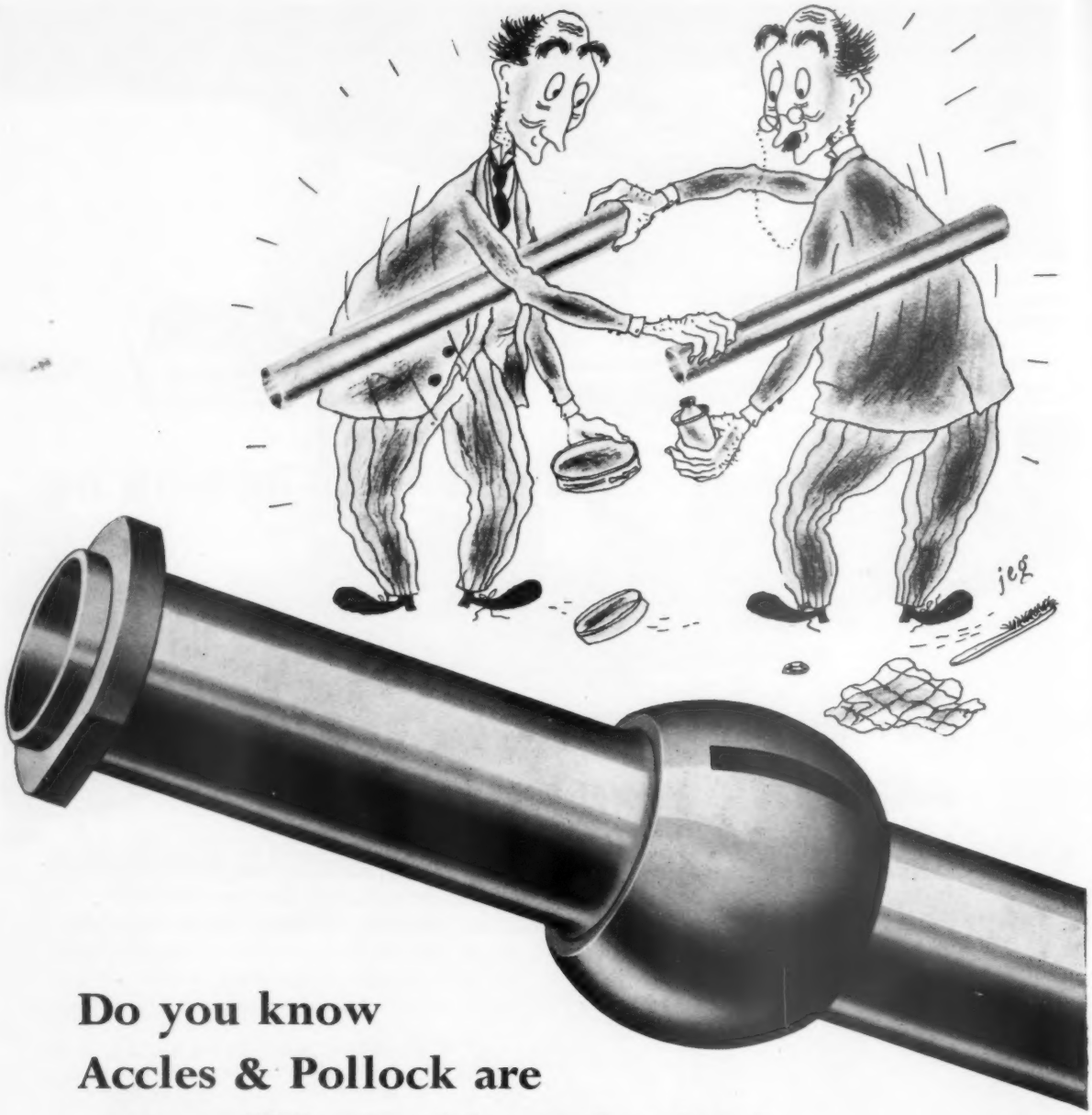
Our full resources are described in this leaflet which will be gladly sent on request (Brochure No. Adv 9a). Engineers are available to discuss your requirements, actual or projected, at any time.

ADAMS BROS & BURNLEY LTD

ELMGROVE ROAD • HARROW • MIDDLESEX

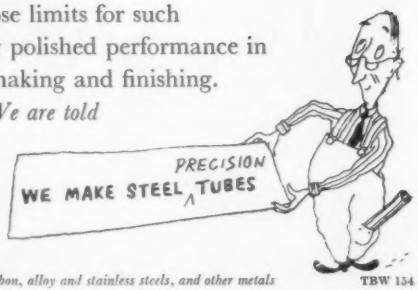
Tel: Harrow 6411 (5 lines) *Grams: Rhodonite Harrow*

MASTERS OF METAL PRODUCTS SINCE 1919



Do you know Accles & Pollock are very polished with steel tubes?

Accles & Pollock are adept at making seamless tubes to very close limits for such purposes as hydraulic lifting apparatus. They also put up a very polished performance in honing and indeed, at anything that calls for real skill in tube making and finishing. *Accles & Pollock publish a book called "Practice and Specifications". We are told it is a very useful reference book for Designers, Works Managers and Production Engineers. A copy will be sent on request.*



Accles & Pollock Ltd., Oldbury, Birmingham · A (TI) *Company · Makers and manipulators of precision tubes in plain carbon, alloy and stainless steels, and other metals*

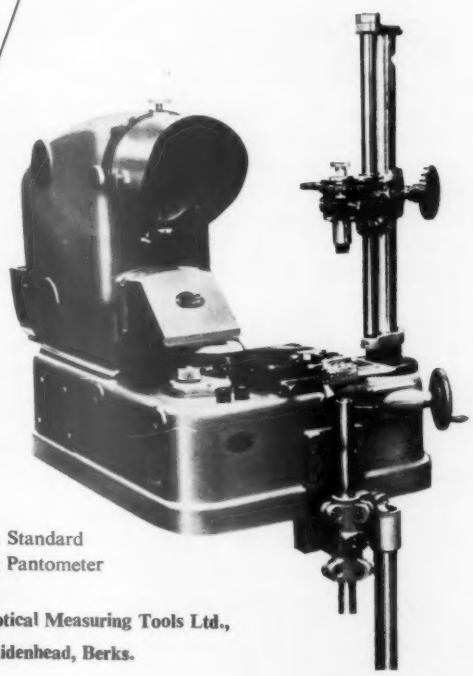
TBW 154

for accurate and rapid checking of turbine blades

Manufactured to the high precision standards associated with all products of Optical Measuring Tools Ltd., the standard and Model "E" projection Pantometers are designed for the rapid and accurate inspection of parts having 3 dimensional contours such as turbine blades.

Model "E" is designed for experimental work requiring frequent changes in blade profile, and gives a magnification of 10 x on a screen 24 in. x 12 in.

OMT
PROJECTION
PANTOMETERS



O.M.T. Standard
Projection Pantometer

Products of Optical Measuring Tools Ltd.,
Maidenhead, Berks.

SALES ORGANISATION FOR THE NEWALL GROUP OF COMPANIES

Write for illustrated brochure to

NEWALL GROUP SALES LIMITED

PETERBOROUGH

Phone: Peterborough 3227-8-9

"It's all works and no space!"

said the Works Manager

He didn't look good at all. All the marks of a long spell of strain. "For months I've been doing the impossible", he bawled, as we threaded our way through the factory. "And because I did it last time they think I can do it again. Not a square inch of floor space, and now *I'm told to find room for a test bench . . ." We stopped him before he exploded. Gently we told him his worries were at an end. We were from Yale. We'd been called in by the management to plan a new scheme for materials handling.*

"Materials handling? . . . that's what I told them six months ago! Clear at least three aisles and we could stack to the end bay northlight . . . Well, well.

Here, let me show you the annexe . . ."

He moved like a different man. He had ideas. We had ideas. Together we plotted a scheme that gave him just what he wanted. And, not surprisingly, we pleased the management too — when they saw the turn their costs would take.

IS LACK OF SPACE RESTRICTING YOUR OUTPUT?

Yale's versatile

"WORKSAVER"

is specially suitable for smaller plants

AMONG the wide range of Yale handling equipment the "Worksaver" series of electric trucks is of special interest to factories where restricted space or low-load floors have previously made mechanical handling impractical. Its small size, light weight and extreme ruggedness give big-truck advantages with small-truck economy and convenience.

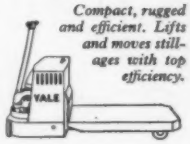
It will lift, move and stack raw materials or finished products. It saves time, space and manpower. You can ride it or walk it. And it will start cutting costs from the minute you put it to work.

The "Worksaver" is available in five basic types : pallet, low-lift platform, high-lift platform, fork-lift and tractor.

FORK LIFT

Lifts, moves and stacks over low-load floors: saves time, space and manpower wherever it's put to work.

PLATFORM



Compact, rugged and efficient. Lifts and moves still-ages with top efficiency.

TRACTOR

A powerful and manœuvrable tractor unit to pull trailers or trailer trains with up to 700 lbs. drawbar pull.

PALLET *Built to stand up to rugged jobs. Lifts and moves maximum load pallets with ease and accuracy.*

YOU GET ALL THESE ADVANTAGES WITH THE "WORKSAVER"

- *Manœuvrable in small spaces and narrow aisles.*
- *Light weight with great strength and power permit heavy duty work on low-load floors.*
- *Dead man control cuts power and applies brakes automatically in emergency.*
- *Simple fingertip controls—unskilled staff can move, lift and stack with speed and safety.*
- *Low initial cost, low running cost, economical maintenance, long life.*

MATERIALS HANDLING EQUIPMENT

MADE IN ENGLAND BY

YALE

REGISTERED TRADE MARK

THE YALE & TOWNE MANUFACTURING COMPANY, MATERIALS HANDLING DIVISION. DEPT. U.4, WEDNESFIELD. STAFFS. PHONE: WILLENHALL 630

Fast High Precision MILLING *and Automatic* HYDROCOPYING

– FORMS for DIES · PROFILES for CAMS etc.

SWISS

'RIGID' MILLING MACHINES

PLANO-MILLING MACHINE P1200

Equipped with 3 Boring and Milling Heads. Table Size—1200 x 3000 mm.

AUTOMATIC HYDROCOPYING VERTICAL MILLING MACHINE—VS5

(Single or Multi spindle machines available) for automatic milling of big dies and forms of all kinds. Table Size—2500 x 650 mm.

AUTOMATIC HYDROCOPYING MILLING MACHINE—KA100 Series

(Single or Multi Spindle Head machines available) Forms for dies, profiles for cams, etc.

Table Sizes—
1500 x 400 mm.
2000 x 600 mm.
2350 x 600 mm.

Full technical information on the above machines and details of the complete extensive range of the Swiss 'RIGID' machines will be sent on request.

SOLE U.K. DISTRIBUTORS

DOWDING & DOLL LTD

346 KENSINGTON HIGH STREET, LONDON, W. 14

Telephone: WESTERN 8077 (8 lines) *Telegrams*: ACCURATOOL HAMMER LONDON

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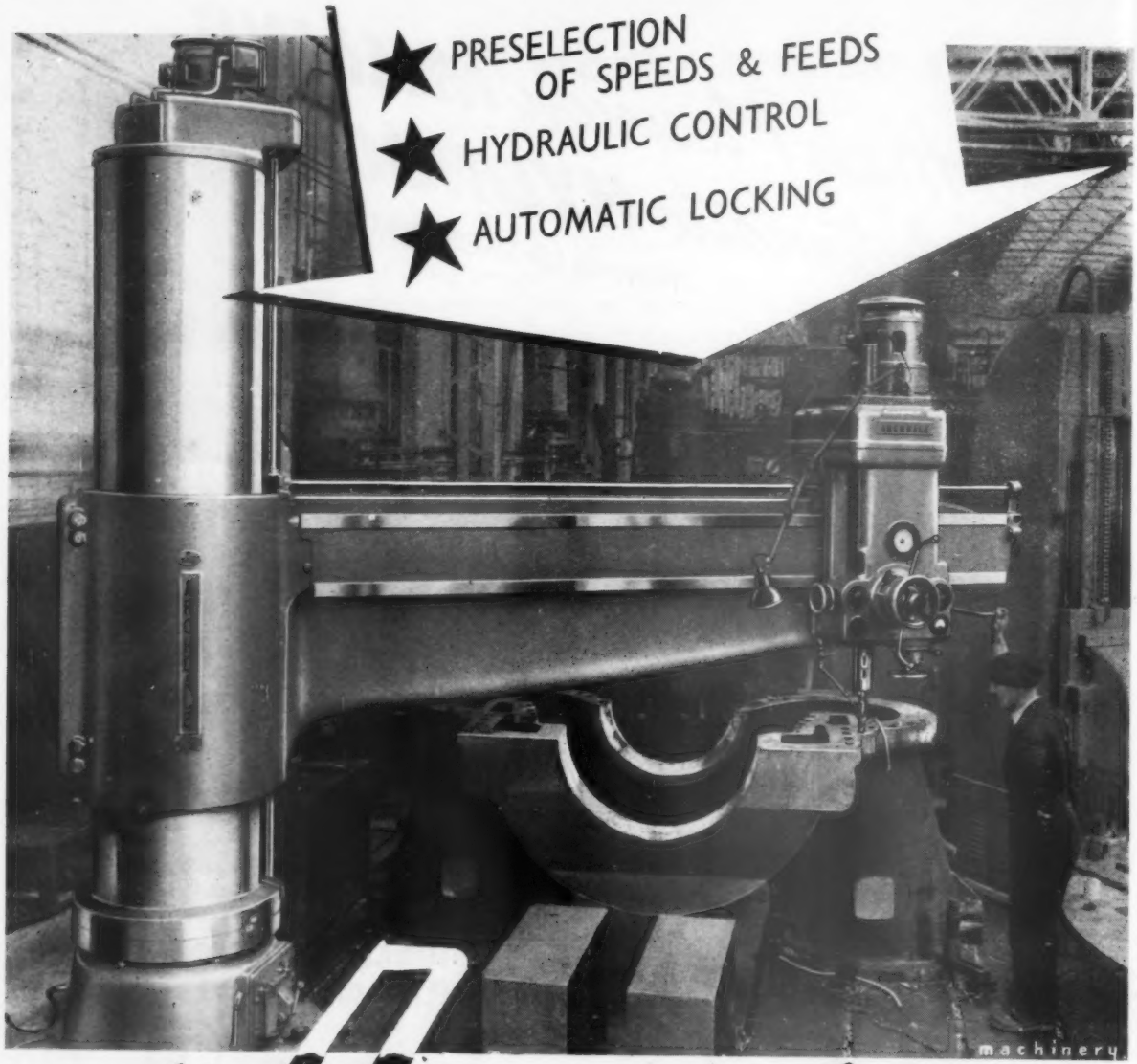
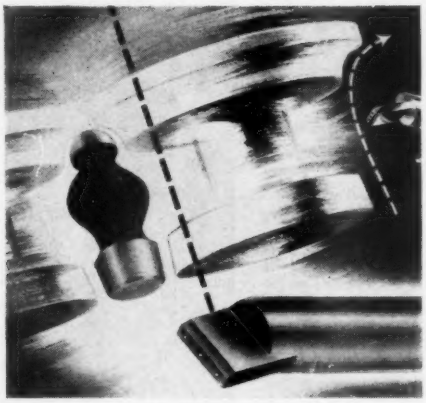


The Archdale HYDRAULIC "preselect"

gives high performance on turbine casings at B.T.H. RUGBY

★ These versatile and powerful machines, with hydraulic control and pre-selection of feeds and speeds, show outstanding results wherever they are installed. Capacity is 4 in. from solid in cast iron and 3½ in. in steel. There are 22 speeds, 11 to 1450 r.p.m. and 18 feeds 8 to 540 r.p.i. Sizes from 5ft. to 12 ft. spindle radius.

JAMES ARCHDALE & CO. LTD. BIRMINGHAM 16 · SOLE SELLING AGENTS: ALFRED HERBERT LTD. COVENTRY



the artisan's diamond

The basic tools of a craft can often be improved by mass production methods. The humble hammer head is now finished on a Centreless Grinder. The tandem grinding wheels are formed to the required profiles with Dianyf Blade type Diamond Truers. Dianyf Tools are available for most production form grinding operations. They improve the accuracy of the finished product and are more economical than conventional diamond tools.

LM VAN MOPPES & SONS (DIAMOND TOOLS) LTD
BASINGSTOKE · HAMPSHIRE · ENGLAND

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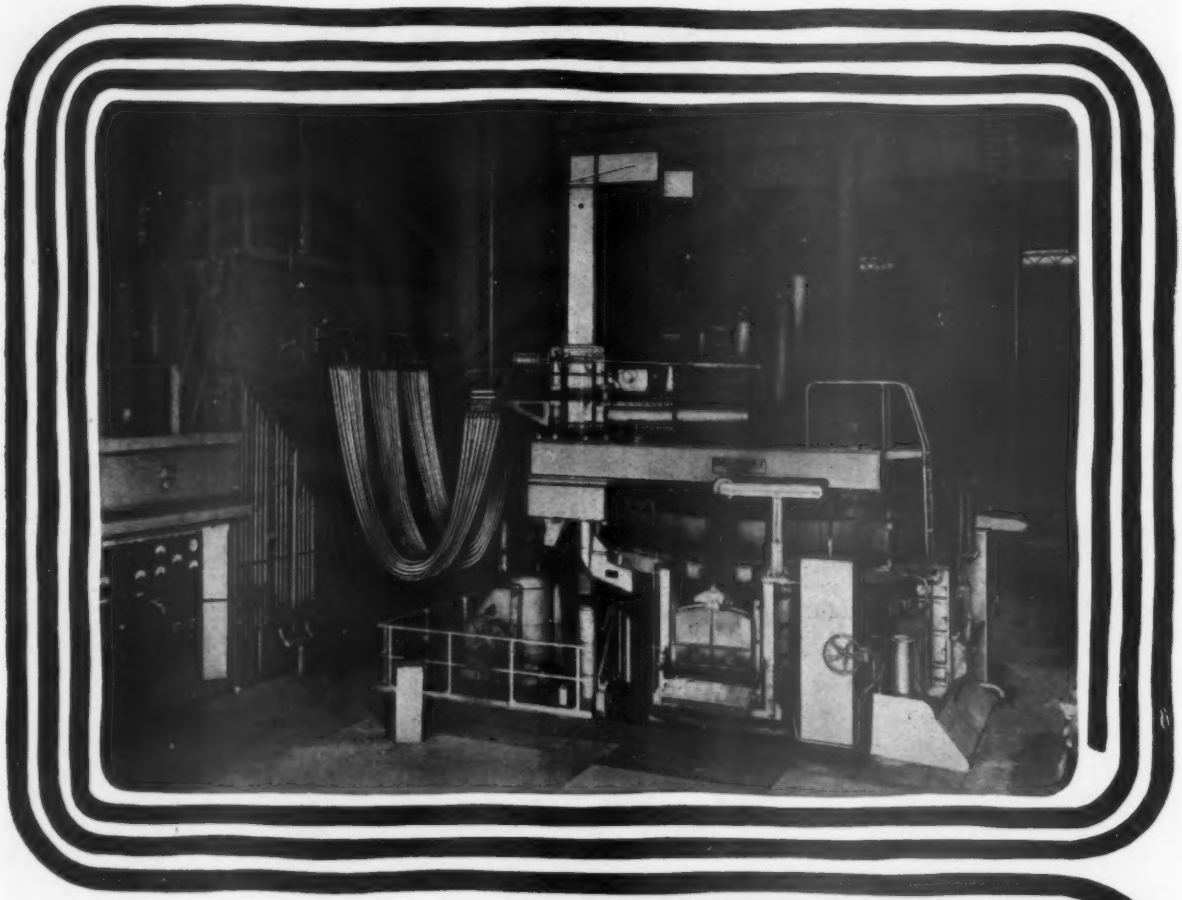


Having a hand in Productivity

In every industry or trade, electrical equipment is the key to modern production methods. There are probably more production-boosting and money-saving devices than you know of. Your Electricity Board can help you and give you sound advice.

They can also make available to you, on free loan, several films on the uses of electricity in Industry — produced by the Electrical Development Association.

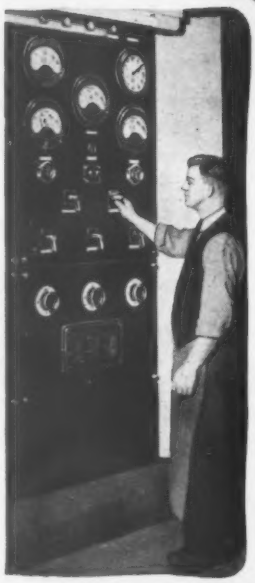
E.D.A. are publishing a series of books on "Electricity and Productivity". Four titles are available at the moment; they deal with Higher Production, Lighting, Materials Handling, and Resistance Heating. The books are 8/6 each (9/- post free) and the Electricity Boards (or E.D.A. themselves) can supply you.

The British Electrical Development Association,
2 Savoy Hill, London, W.C.2.

Steel - exactly!

The hand is on a lever, a small lever that is light to operate. But through that lever the hand is controlling the powerful current necessary to melt 20 tons of steel in an electric furnace. And because the furnace is electric the hand is doing much more than that. It is controlling the making of steel quickly, economically, exactly. Whether it be for production of exact-analysis steel or of cast iron from the lowest grade of scrap, there is nothing to beat the electric furnace. But the electric furnace is

only one of the aids to higher Productivity that Electricity can bring you.



Electricity a Power of Good for PRODUCTIVITY

The best lathe investment is a HARRISON

...FOR ALL ROUND PERFORMANCE...

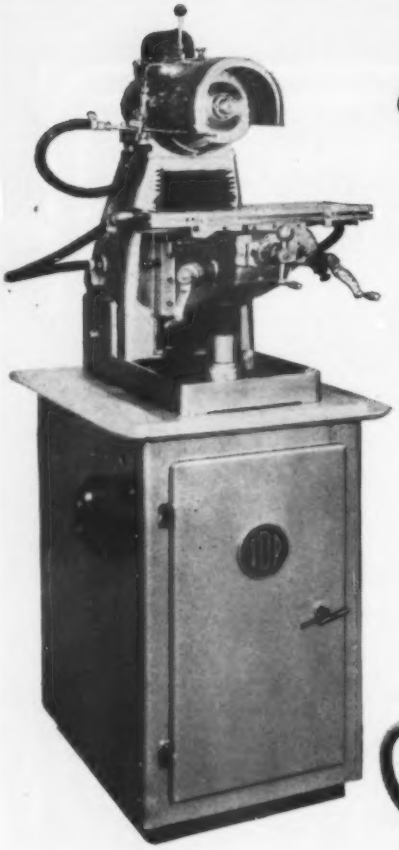
fast metal removal, fine finish, adaptability and best value for money you cannot make a better choice than the . . .

Harrison

11" SWING LATHE

Swing over Bed .....11 3/8"
Swing in gap .....18 3/4"
Spindle bored .....1 1/4"
All-geared headstock
8 or 16 speeds

T. S. HARRISON & SONS LIMITED • HECKMONDWIKE • YORKS

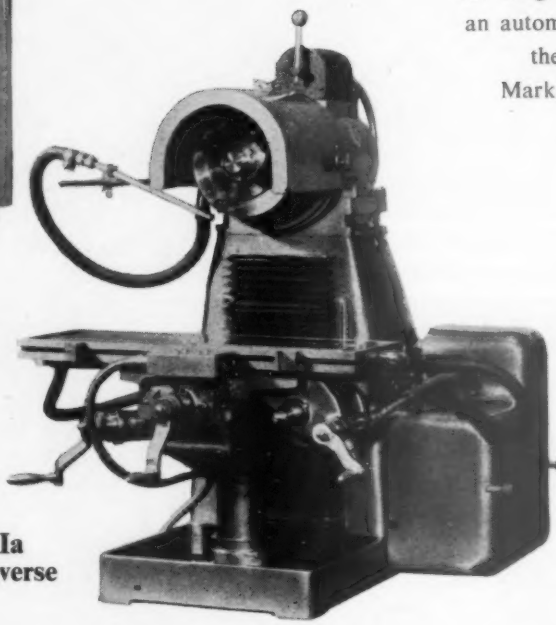


CUTTING AND TOOL GRINDING MACHINE

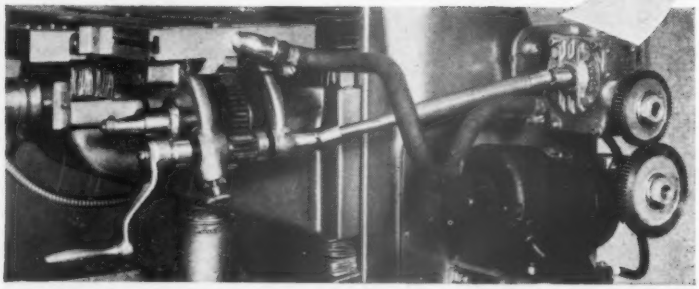
The G.F.3 was introduced originally to satisfy the demand for a small universal machine suitable for use with Neven Diamond Impregnated Tools for chipbreaker grinding and similar tool room work, and certain production operations.

The Mark II model has been developed on the same lines as the original Mark I, but with many improvements, and also a far higher degree of precision. As a result of numerous requests we have now added to our range the Mark IIa model with an automatic traverse; this retains the original simplicity of the Mark II with the addition of a sturdy and compact traversing unit.

G.F.3 MARK II



G.F.3 MARK IIa
with automatic traverse



Close-up of assembly with cover removed

IMPREGNATED DIAMOND PRODUCTS LTD. - GLOUCESTER ENGLAND

TELEPHONE 21164 (3 LINES) TELEGRAMS IMPREG GLOUCESTER

'BEMAG' the REVOLUTIONARY APPROACH to SINGLE, BATCH and MASS PRODUCTION BORING

Automatic Preselection of Co-ordinate Settings *completely eliminate Jigs and Fixtures!*

THIS FULLY AUTOMATIC CO-ORDINATE BORING MACHINE is entirely new in its conception

Pre-selection of co-ordinate settings in either direction.

Settings made to .0002″ using unique system of end gauges held in totally enclosed magazines.

Pre-selection of spindle speeds. Speeds and feeds checked by means of tell-tale lamps and illuminated preselectors.

Always automatically clamped when in boring position. Work table accessible on three sides.

Vertical power adjustment of table driven by four synchronised screws with adjustable backlash eliminator.

Table can be completely removed, allowing machining of large bulky components. Infinitely variable milling feed.

No damage done to the machine by incorrect manipulation of controls. Loading of slideways always uniform.

Longitudinal/cross adjustment of Spindle—48″/32″.

Inspect this machine in our Showroom

ROCKWELL MACHINE TOOL CO. LTD.

WELSH HARP, EDGWARE ROAD, LONDON, N.W.2. TELEPHONE: GLADSTONE 0033

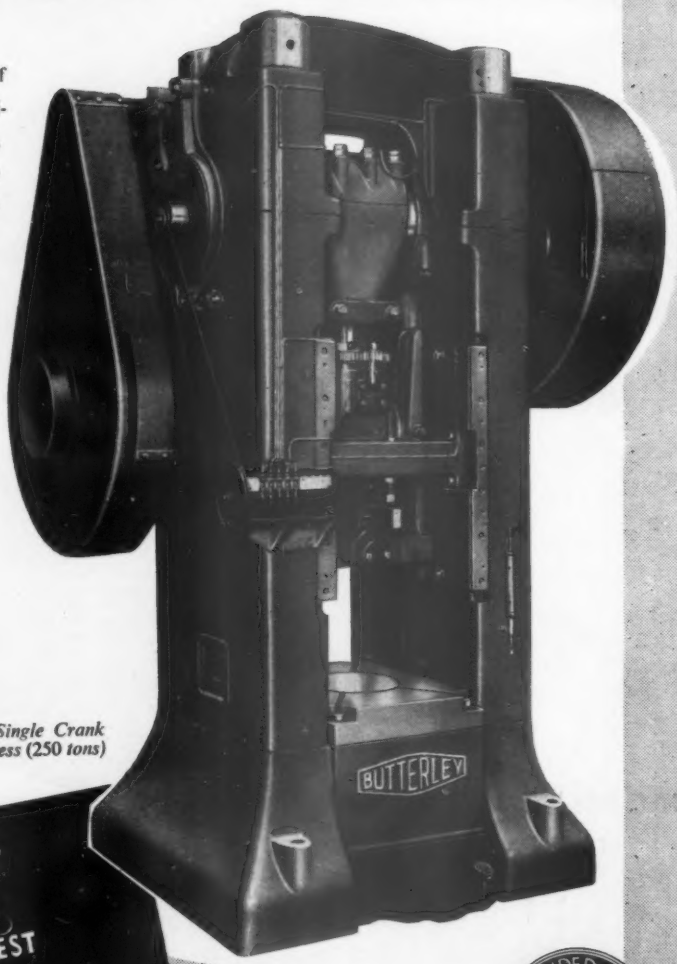
ALSO AT · BIRMINGHAM—TELEPHONE SPRINGFIELD 1134/5 · STOCKPORT—TELEPHONE STOCKPORT 5241 · GLASGOW—TELEPHONE MERRYLEE 2822

BEMAG

SHEET METAL MACHINERY

by BUTTERLEY

The design of every machine in this range of equipment is based on many years of practical experience in the fashioning of metals. All the castings are manufactured in the Butterley foundries, by the Mechanite process, thus ensuring a high duty material suitable for the arduous conditions imposed. Range includes geared and ungeared power presses, press brakes and general machinery for hot and cold working of metals.



7½-26 *Single Crank Press* (250 *tons*)

FULL DETAILS OF BUTTERLEY SHEET METAL MACHINERY WILL BE SUPPLIED ON REQUEST

FOUNDED 1790

THE BUTTERLEY COMPANY LIMITED

RIPLEY · DERBY · ENGLAND Tel: RIPley 411 (9 lines)

LONDON OFFICE: 20, ASHLEY PLACE, VICTORIA, S.W.1. Tel: VICtoria 8023/4/5

SM 5

butt-welded tools
These tools, electrically butt-welded, have high speed steel ends and carbon steel shanks. They are hardened and ground ready for use and machine ground on base. A range of tools for heavy duty is also available.
JESSOP-SAVILLE high speed steel
ARKWELD AND TRIUMPHWELD
Send for standard price list and details
WM JESSOP & SONS LTD
BRIGHTSIDE WORKS SHEFFIELD
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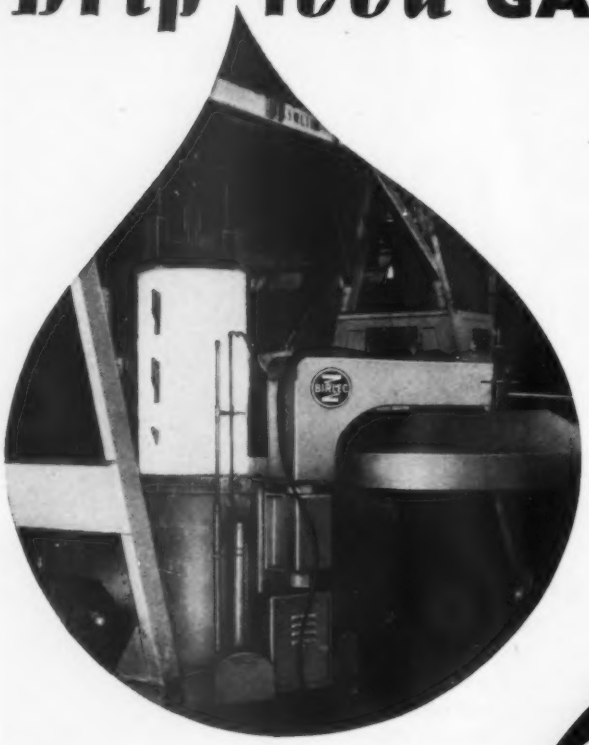
TRIUMPH WORKS SHEFFIELD

Drip-feed GAS CARBURISING



Birlec pit gas carburisers can now be supplied with the "drip-feed" atmosphere generation system, as an alternative to using a separate generator and enriching the processed town's gas with butane, methane, etc. In the "drip-feed" furnace a suitable organic liquid is dripped into the heated charge chamber where it vaporises and cracks to form the carburising gas. The liquid comprises ingredients readily obtained from chemical suppliers at a cost not exceeding 10/- per gallon.

Illustrated are two 65 kW pit gas carburisers using "drip-feed".

with STANDARD PIT BIRLEC GAS CARBURISERS

In instances where there is little floor space available, "drip-feed" may be preferred to the use of an external generator. It is also slightly cheaper in capital cost, although this advantage is ruled out if three furnaces (which can utilise the same generator) are installed. On running costs there is little to choose between them and both show considerable economies over the pack carburising process. Depending on the size of furnace used, charge handled and case-depth required, the carburising cost in standard Birlec pit furnaces varies between 1d. and 1½d. per lb.

BIRLEC LIMITED

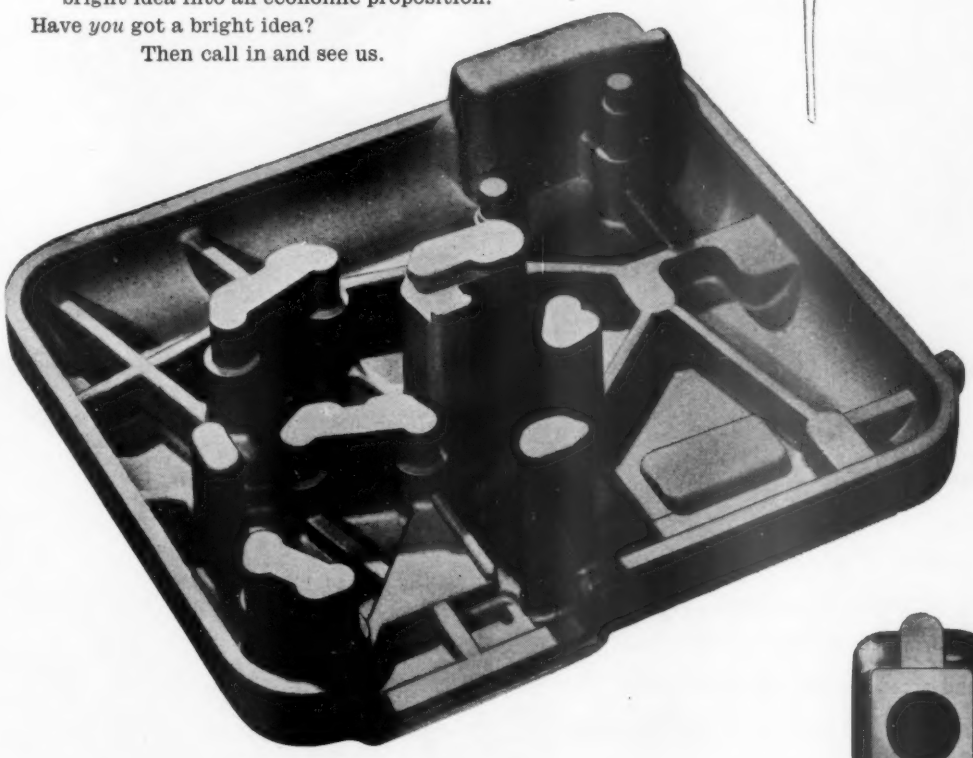
Member of the AEI Group of Companies.

ERDINGTON . BIRMINGHAM 24

also LONDON · SHEFFIELD · GLASGOW . NEWCASTLE-ON-TYNE

why pick on us?

Hilger & Watts picked on us
to cast the parts for their new Cowley
Automatic Level because they wanted it
produced quickly, cheaply and accurately.
The Cowley Level replaces the Dumpy and spirit
levels, with the advantage that it can be
used by unskilled labour. Pressure die
casting has turned what started as a
bright idea into an economic proposition.
Have *you* got a bright idea?
Then call in and see us.



the whole in one

BDC

CERTIFIED ZINC ALLOY ZAMCA DIE CASTERS

BRITISH DIE CASTING AND ENGINEERING COMPANY LTD.

EDWARD ROAD · NEW BARNET · HERTS · TELEPHONE: BARNET 9211

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CRC 26

The WM '85'

8½" CENTRE LATHE

A heavy duty lathe suitable for use with the modern carbide cutting tools

Sets a high standard of precision output, fast production and simplicity of operation, smooth vibrationless performance at high speeds; robust construction; and accessible disposition of control.

10 H.P. MOTOR

SPEEDS 21—945 r.p.m.

These booklets show that W & M designers have produced in the WM85 and 70 junior ideal lathes for production and general machine shop service. Copies of these booklets will be forwarded free on request.

WOODHOUSE & MITCHELL

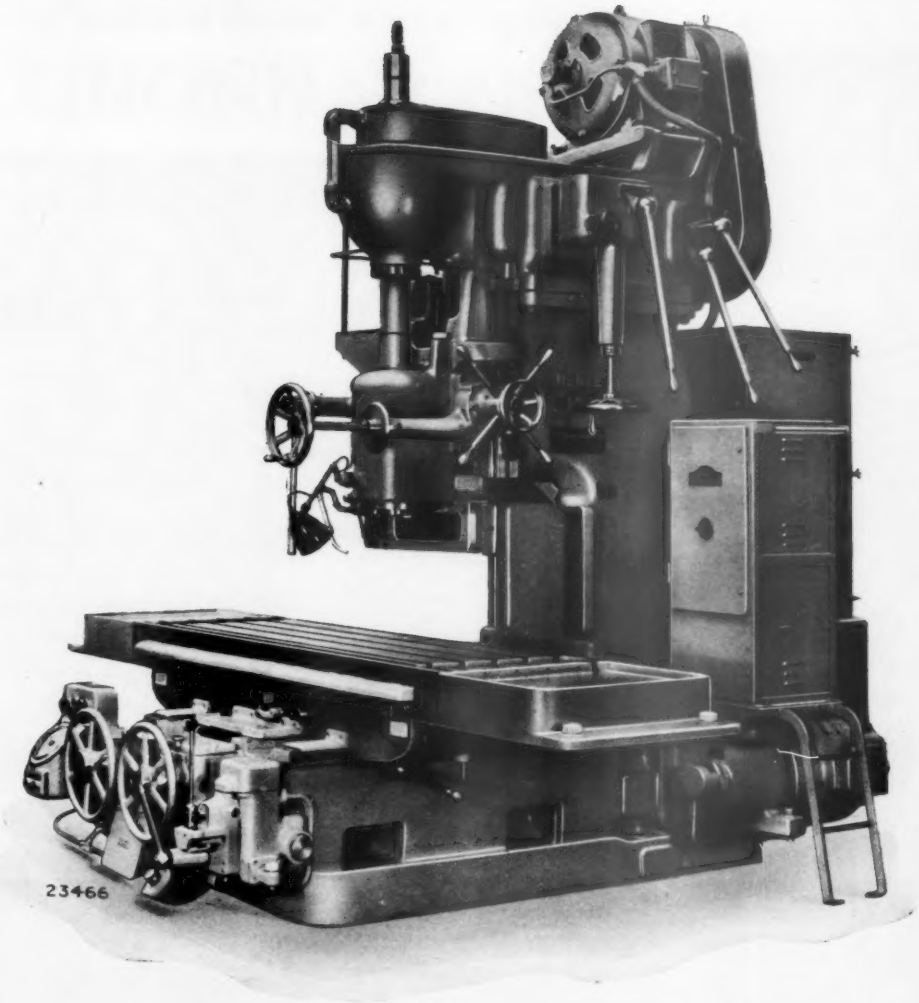
(PROPRIETORS: THOS. W. WARD LTD)

WAKEFIELD ROAD · BRIGHOUSE · YORKS

PHONE: BRIGHOUSE 627 (3 LINES) · GRAMS: 'WOODHOUSE, BRIGHOUSE'

WM 14

HERBERT



HERBERT No. 28A VERTICAL MILL

62″ x 20″ x 30½″

A machine of great power and strength, suitable for the heaviest work including negative rake milling.

Precision ball and roller bearings to spindle, anti-friction bearings throughout main drive. Two-speed motor gives 32 spindle speeds. Electronic feed infinitely variable from 0.8in. to 40in. per minute. Circular table with self-contained motor drive can be supplied.

EARLY DELIVERY

Full particulars on request from:—

HEAD WORKS—Phone. 88781.

ALFRED HERBERT LTD · COVENTRY

No skeletons in the cupboard

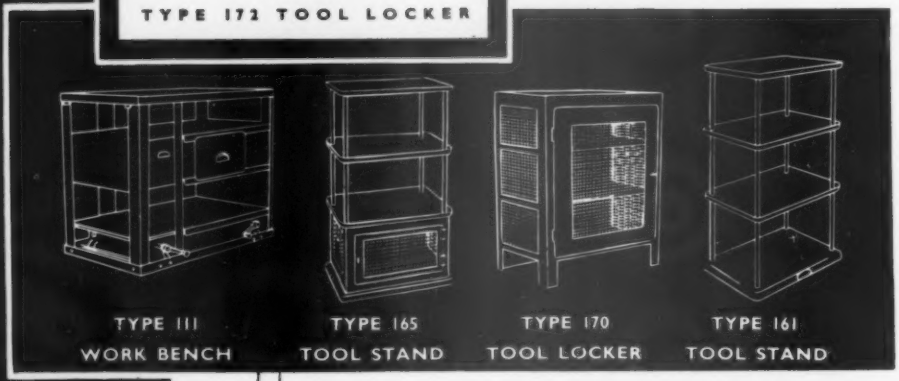
when STEELPACT furniture is keeping production tidy. Work is kept off the floor and tools are where they can be found without fumbling. This essential furniture is adaptable, may be extended into multiple units and is available in various forms and sizes. You will be surprised how little it costs to be efficient with

STEELPACT

WORKSHOP FURNITURE

TYPE 172 TOOL LOCKER

Write for illustrated brochure describing:—Permanent, Semi-Portable and Mobile Work Benches, Tool Stands and Lockers. Inquiries also invited for Foremen's Desks and Testing Benches, Erection Trestles and other special or non-standard workshop furniture.



TYPE 111 WORK BENCH | TYPE 165 TOOL STAND | TYPE 170 TOOL LOCKER | TYPE 161 TOOL STAND

FAWCETT PRESTON

furnishers to production

FAWCETT PRESTON & CO LTD BROMBOROUGH CHESHIRE

A METAL INDUSTRIES GROUP COMPANY

FP2/1/P320

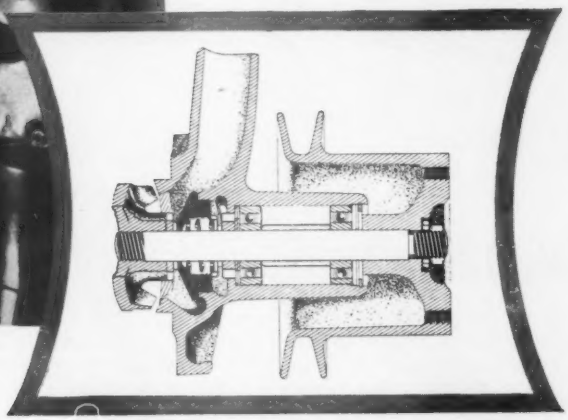
THE CONCENTRIC MANUFACTURING COMPANY

grind automobile water pump spindles on a

CINCINNATI N°.2 FILMATIC

CENTRELESS GRINDING MACHINE

Each spindle is ground twice, the second time being after copper plating; limits for both operations are ±.0002". Production is 15,000 spindles per week, i.e., 30,000 centreless "passes" each 44 hours on one Centreless grinding machine.



Because of its speed and accuracy, the Cincinnati "Centreless" is an ideal machine for grinding all metals, plastics, glass, rubber, ceramic and many composition materials. Cincinnati's Application Engineers are available to discuss *your* grinding problems.

Write for Catalogue G-574-E and for "Principles of Centreless Grinding".

CINCINNATI MILLING MACHINES LTD., BIRMINGHAM, 24

Tinker, Toolmaker Worker, Watchmaker

—THERE'S A BEDFORD FILE FOR THEM ALL

From the flat file for general work to the Warding file for the locksmith, there is literally, a Bedford file and rasp for every known filing purpose to-day. Rolled under careful observation in Bedford's own factory, forged, cut, hardened and tested with precision, these tools have exceptionally long-wearing and hard cutting qualities. Right down to the most delicate file there's craftsmanship in Bedford tools . . . and economy—

if it's a good file it's a

BEDFORD

JOHN BEDFORD AND SONS LTD LION WORKS SHEFFIELD

723

for

HIGH PRODUCTION

at low cost

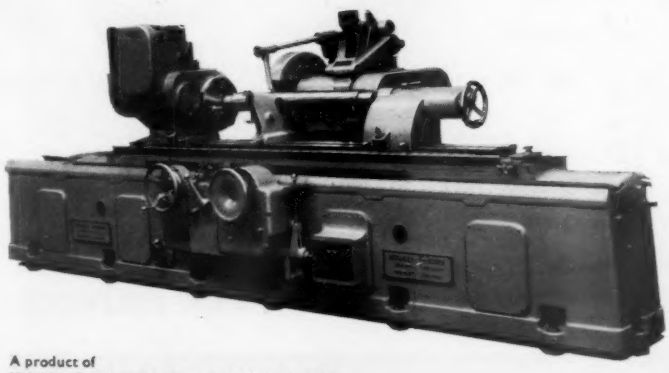
KEIGHLEY
MODEL

KU

HEAVY DUTY UNIVERSAL GRINDING MACHINE

Special features of design ensure high production at low cost, regardless of the length of run. Speed, precision and economical operating are characteristics of the KU Heavy Duty Universal Grinding Machine.

Available in a range of sizes from 18" × 24" to 24" × 96"



- OPERATOR FATIGUE MINIMISED
- HYDRAULIC AND HAND TRAVERSES CANNOT BE ENGAGED SIMULTANEOUSLY
- INFINITELY VARIABLE TABLE TRAVERSE AND SHOCKLESS REVERSE
- DEAD STOP ON AUTO-FEED FOR REPETITION WORK
- MASSIVE PROPORTIONS OF WHEELHEAD AND WORKHEAD ENSURE VIBRATIONLESS OPERATION
- AUTOMATIC PRESSURE LUBRICATION
- RAPID APPROACH AND WITHDRAWAL OF WHEELHEAD UP TO 8"

Please Address Enquiries to

NEWALL GROUP SALES LTD.,
PETERBOROUGH, ENGLAND

A product of
Keighley Grinders (Machine Tools) Ltd., Keighley

Telephone: Peterborough 3227-8-9 Keighley 4294

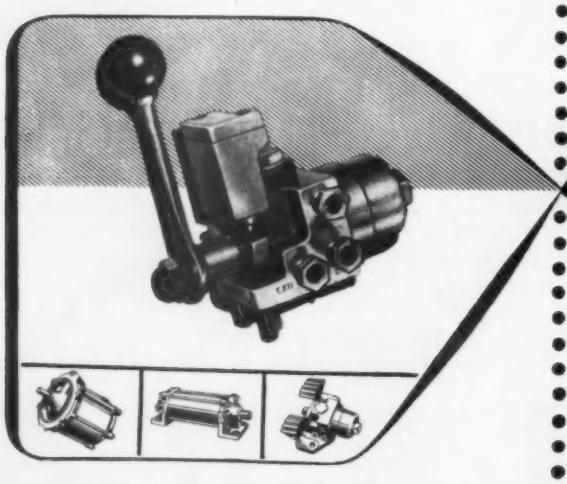
Unique

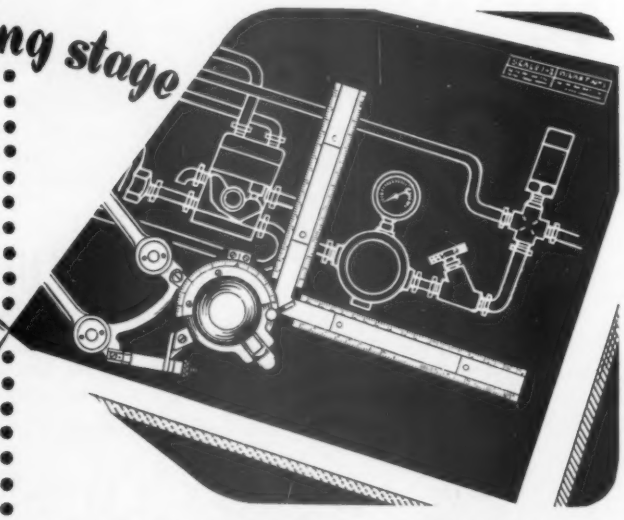
"Newallastic" bolts and studs have qualities which are absolutely unique. They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method

C. P. Newall & Co., Ltd.

POSSILPARK GLASGOW · N

bring us in at the planning stage





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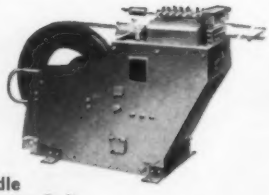

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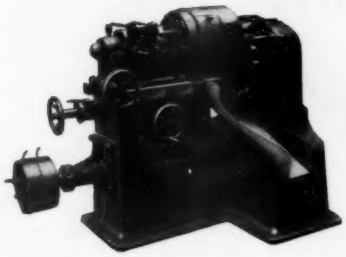

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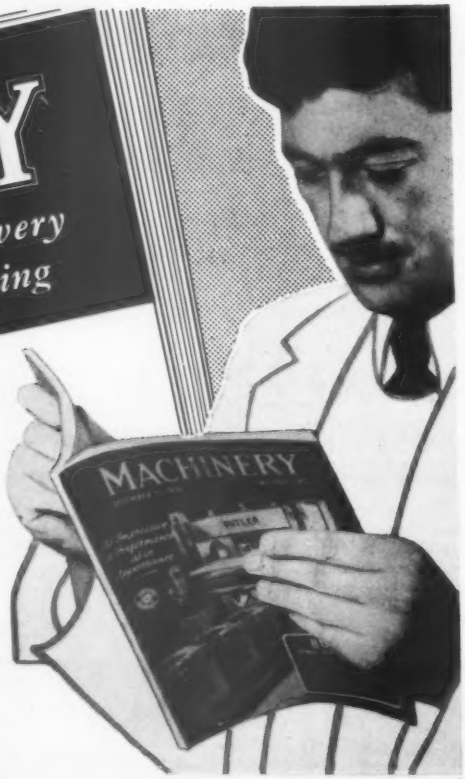

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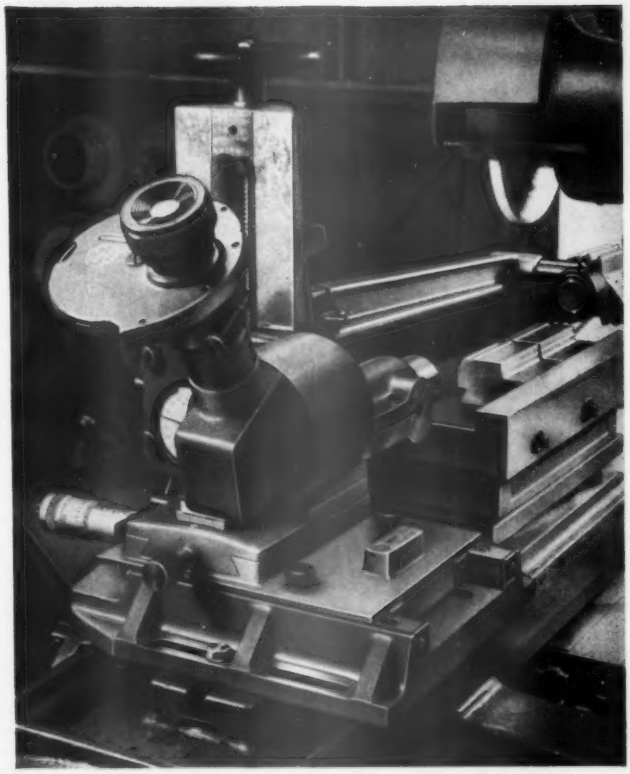

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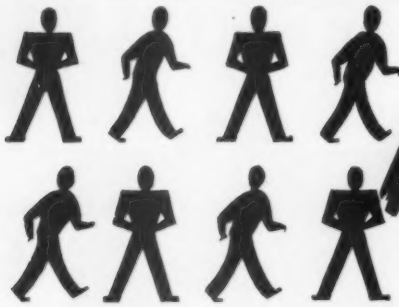

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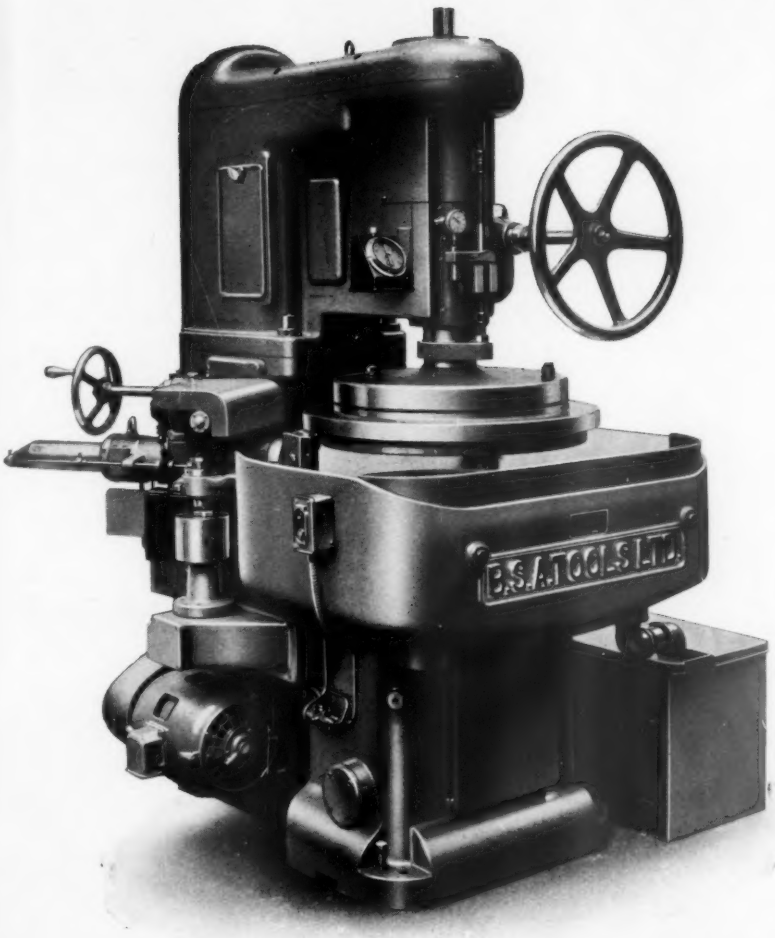

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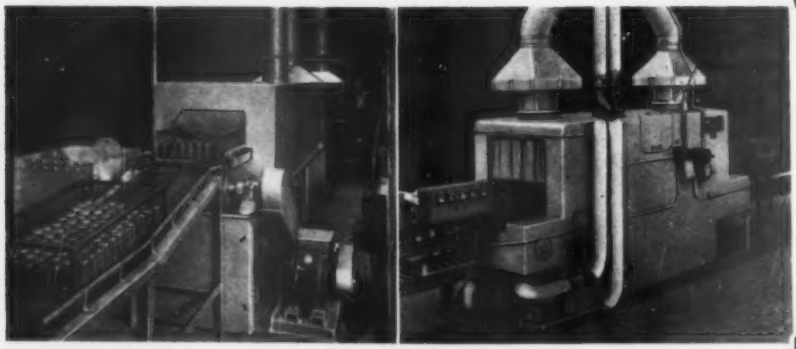
A 'Junior' type machine supplied to a Midlands Motor Car Works



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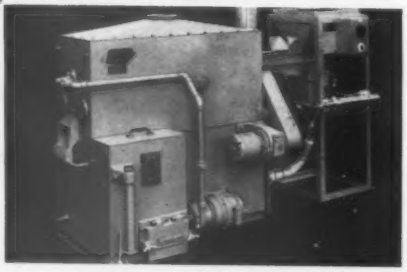

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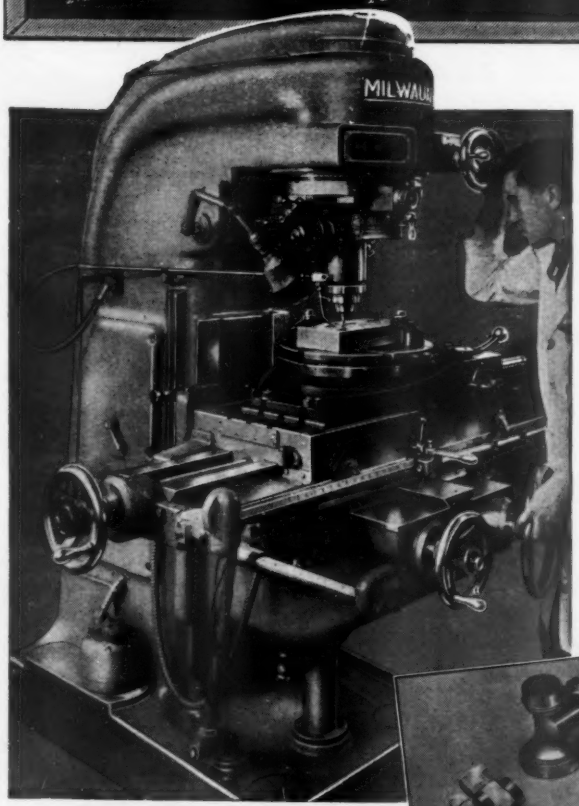

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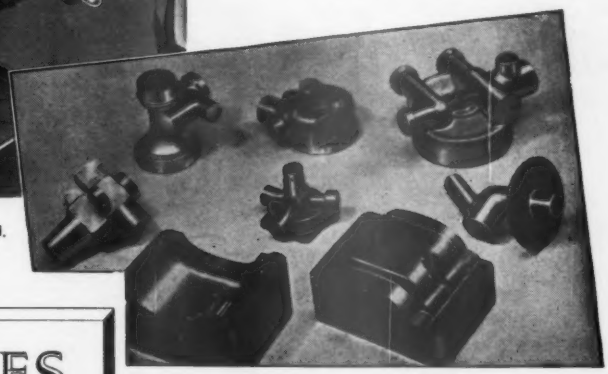

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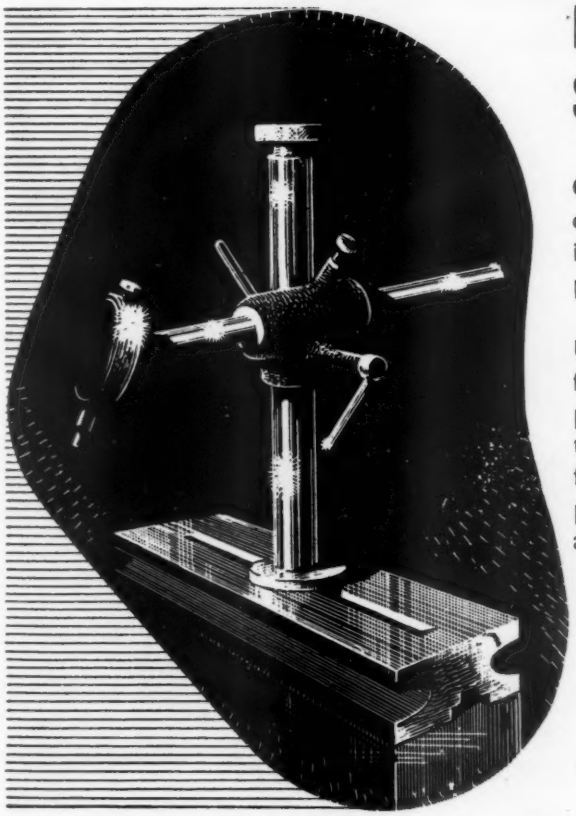

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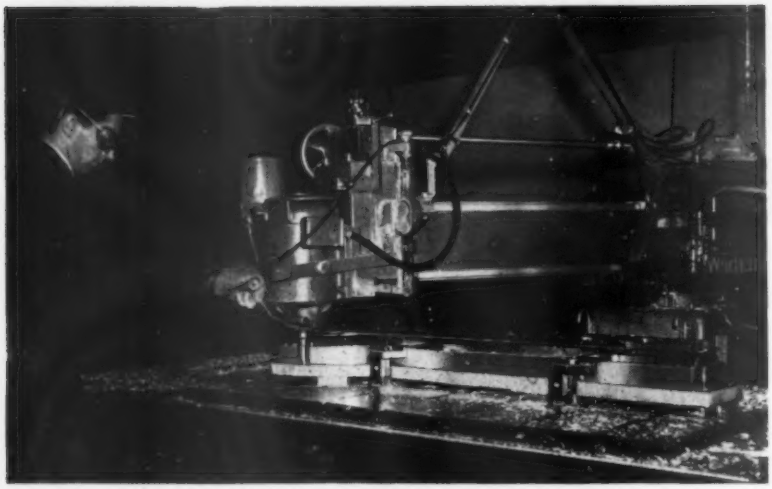

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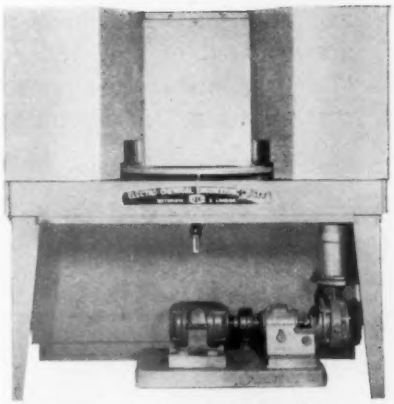

Illustration shows an EFCO DI-PHASE aluminium piston-washing machine built for a new European automobile factory

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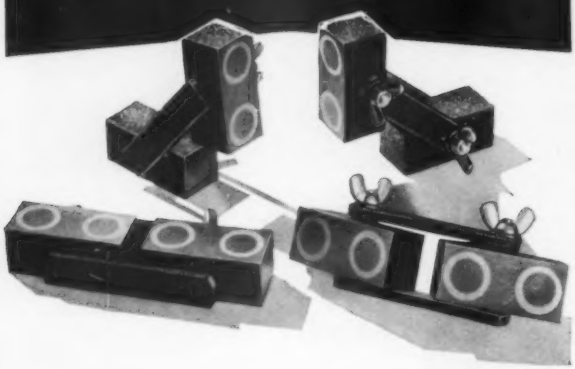

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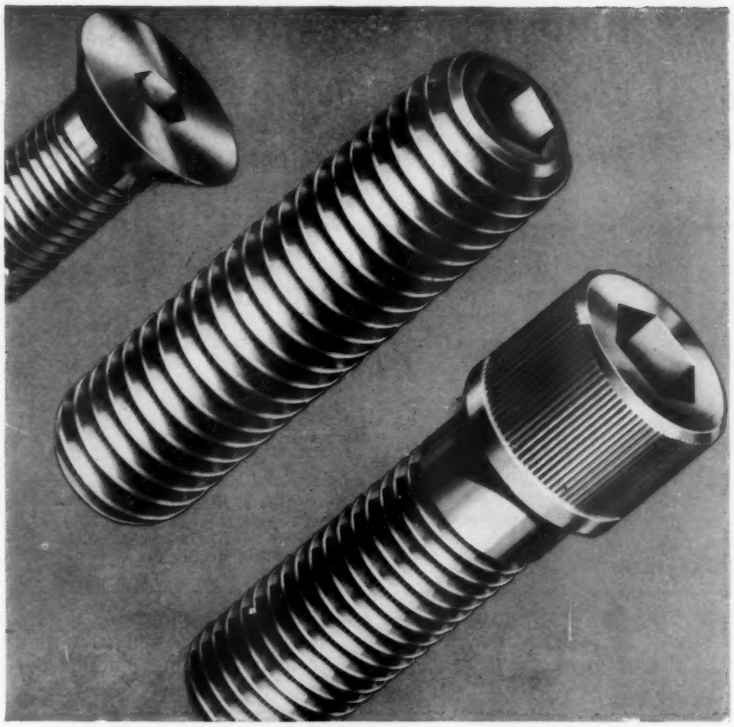

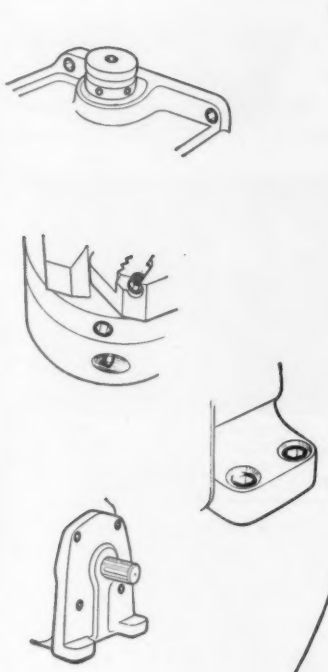

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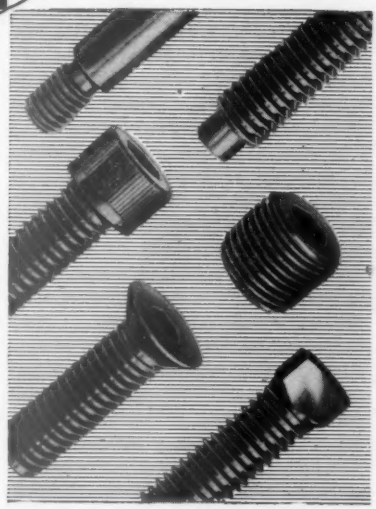

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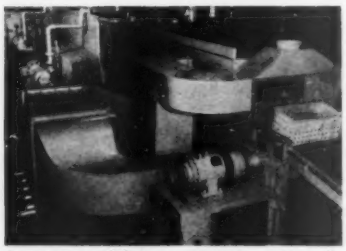
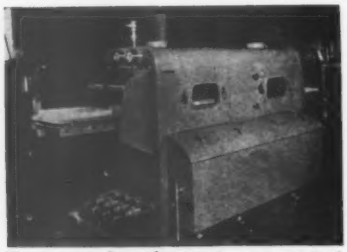
can be designed to meet your particular cleaning problems

This illustration shows a machine cleaning crank cases in the production line. It is equally capable of cleaning small parts in baskets.



A power driven conveyor system is employed with this cleaning machine for ball bearings.



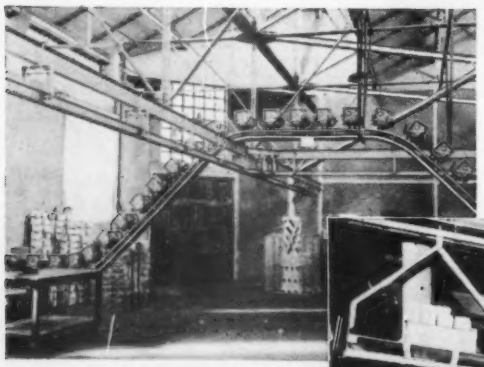
Trays carrying the work are pushed through on a roller conveyor by hand in this cleaning installation.

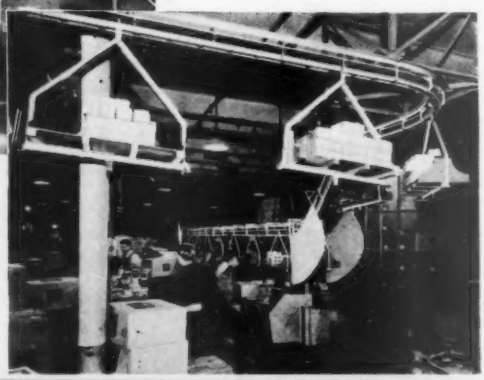
Whilst offering a very wide variety of standard cleaning equipment, it is BRATBY policy, wherever possible to design the machine to meet the particular cleaning problem. Careful study of each individual problem ensures maximum efficiency and economy of the plant in operation. The illustrations show but a few of the specific types of Cleaning Machines designed by BRATBY for individual needs.

Designed and Manufactured by:

BRATBY & HINCHLIFFE LTD · SANDFORD ST · ANCOATS · MANCHESTER 4

DUAL-DIRECTIONAL CONVEYOR SYSTEMS





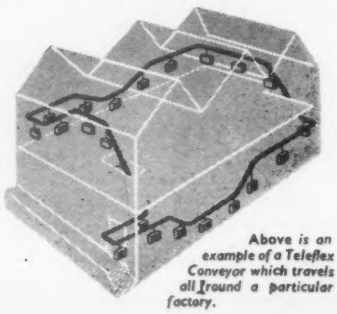
Above: *The Teleflex dual-directional chain Conveyor adopted to carry tins of biscuits.*

Right: *Overhead chain conveyor carrying cigarettes in packing and despatch departments at the factory of Messrs. W. A. & A. C. Churchman.*

Now thoroughly proved in service with some of the most well-known manufacturers the Teleflex Dual-directional Chain Conveyor can be supplied soon after receipt of your order. The design is simple, efficient, well proportioned and perfectly balanced.

Teleflex Conveyor systems are constructed from standardised units which are capable of being formed into individual systems to suit any particular factory or production layout.

Write for illustrated brochures: Cable Conveyors ref: Con. I.P.E. and Chain Conveyors ref: Con. 2 I.P.E.



Above *is an example of a Teleflex Conveyor which travels all* Around *a particular factory.*

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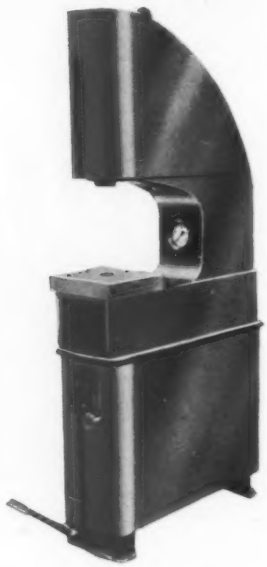

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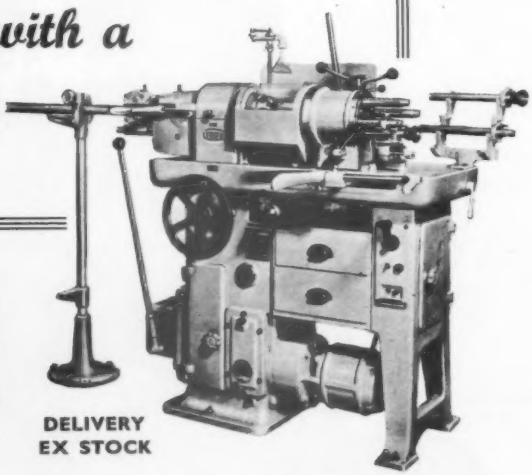

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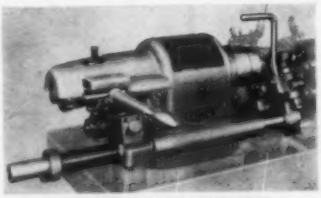

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- Thread chasing attachment available.

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Maximum turning length : 4 1/16".
Spindle speeds : Infinitely variable, 42-2,400 r.p.m. forward and reverse.

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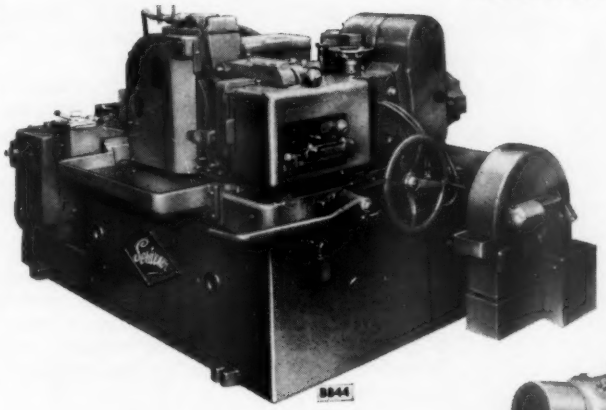

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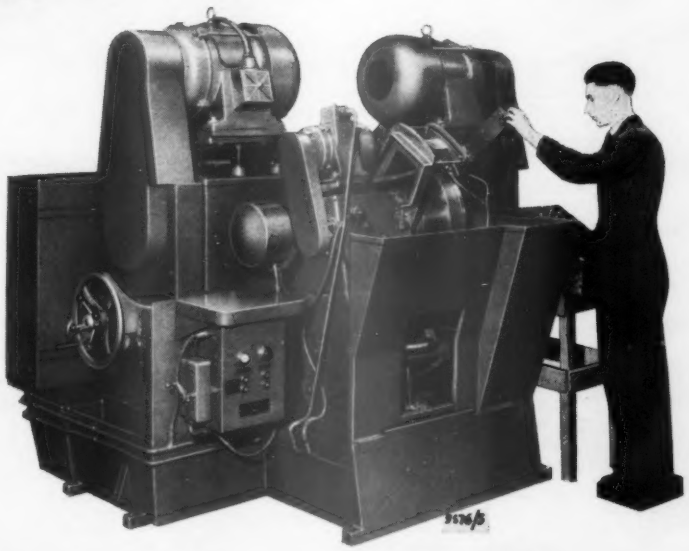

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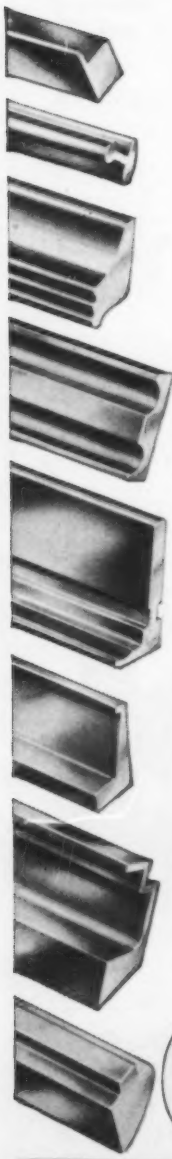

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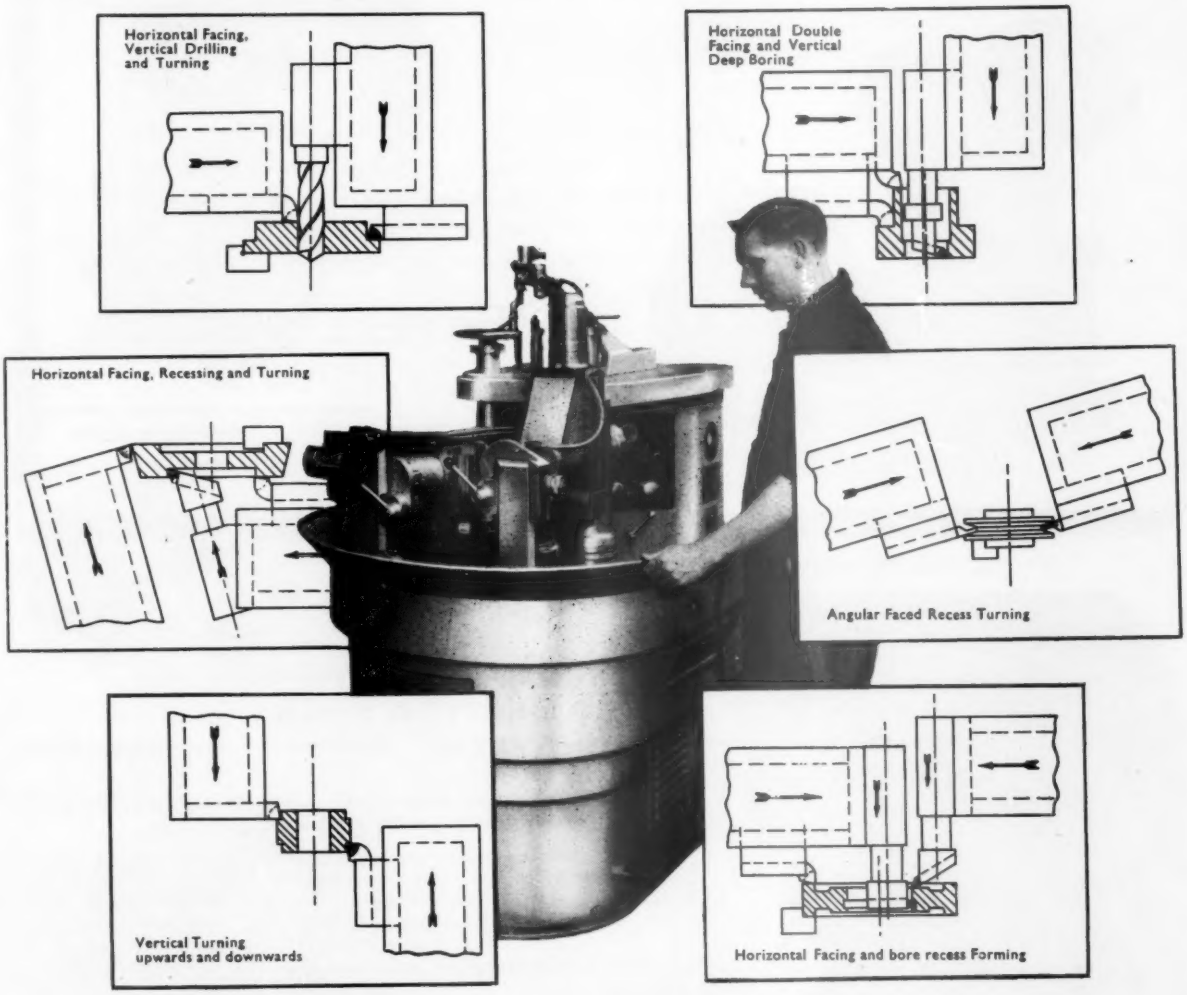
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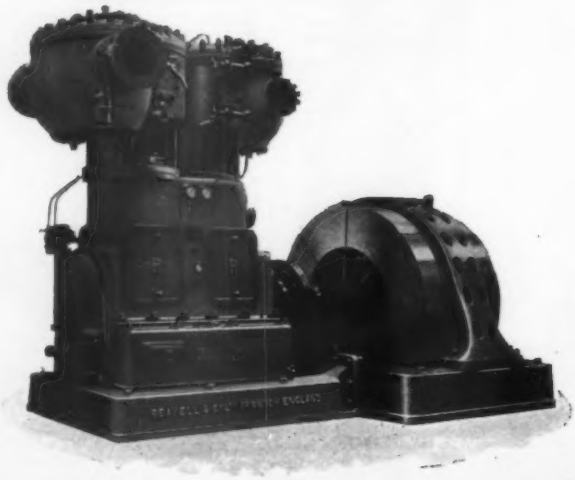

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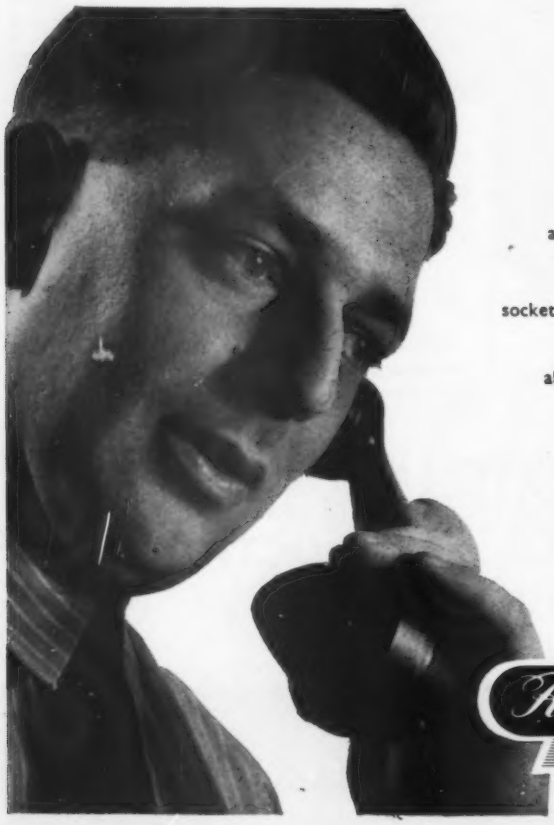

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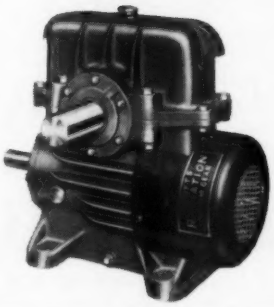

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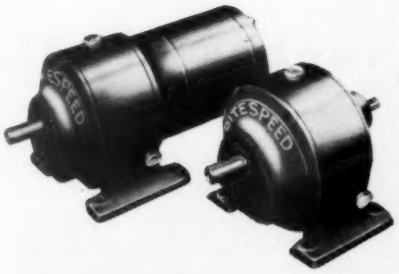

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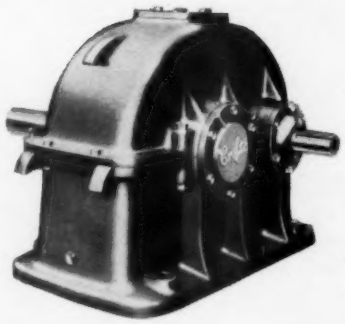

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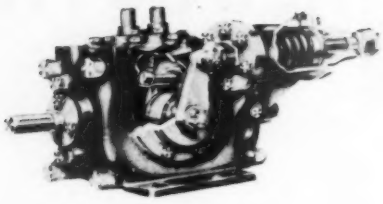

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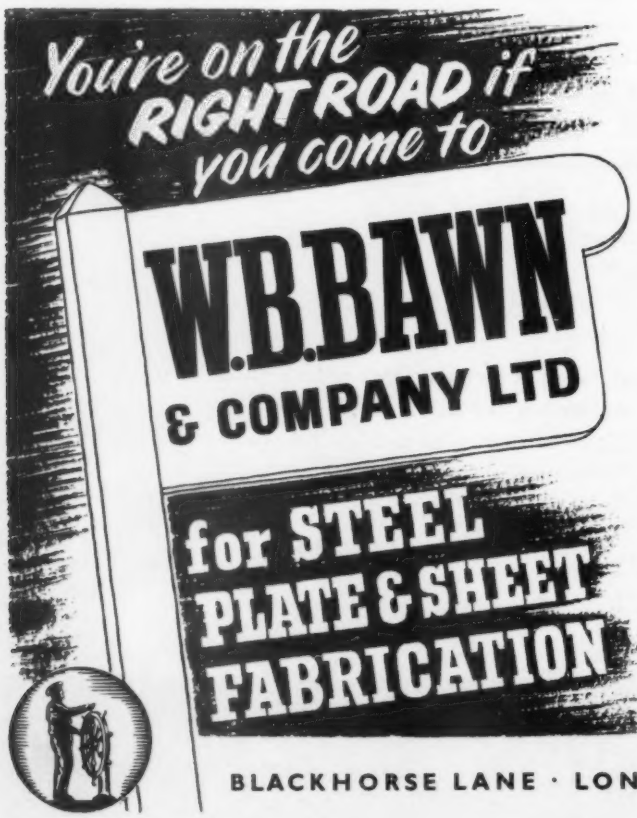

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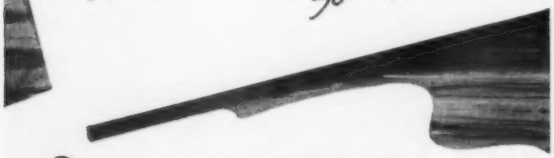

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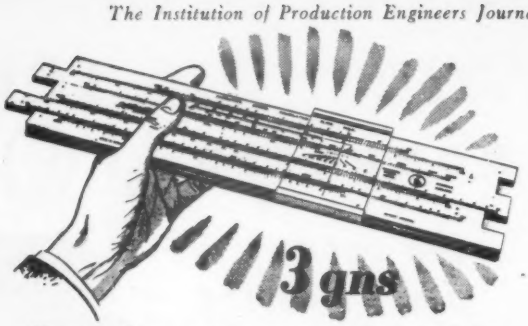

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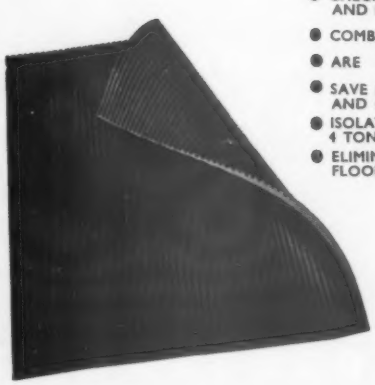

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THIS FINE BORING MACHINE SHOWS A BIG SAVING IN THE *Finish*

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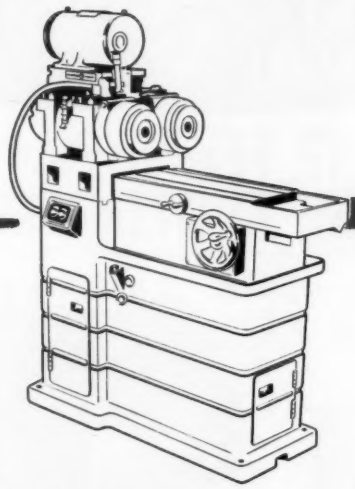

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So whether it's the single-ended type S.E.14 shown above or the double-ended type D.E.14, ring Stanley Howard today for further details—without obligation, of course.

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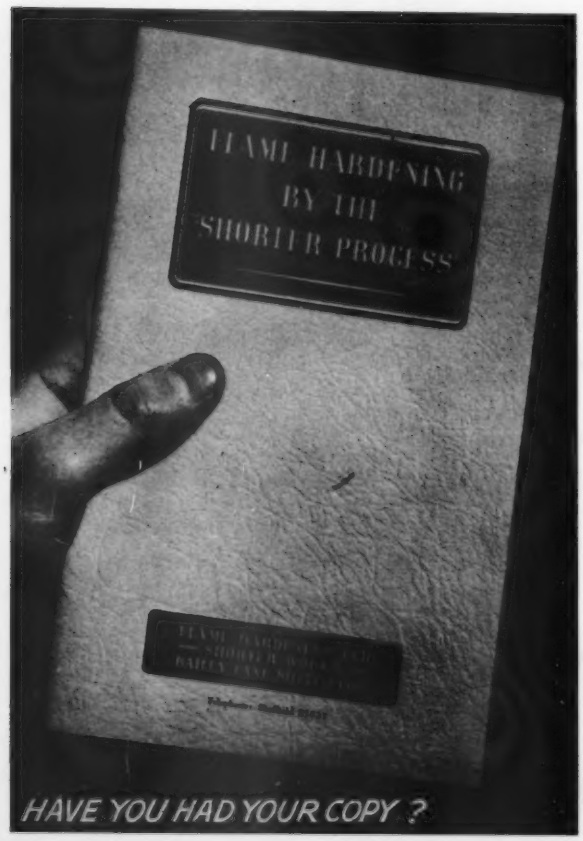

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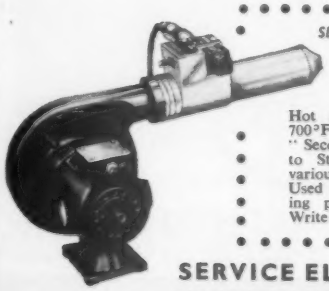

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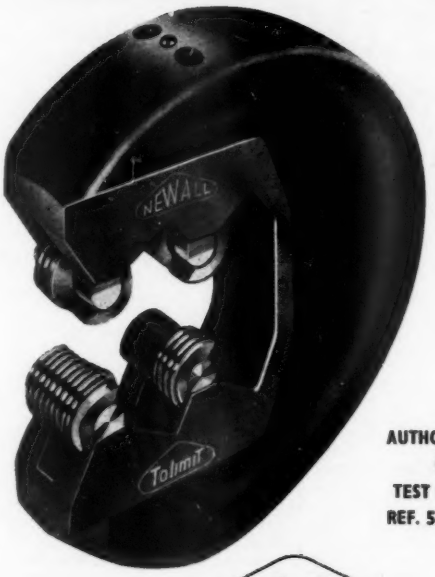

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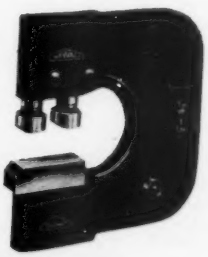

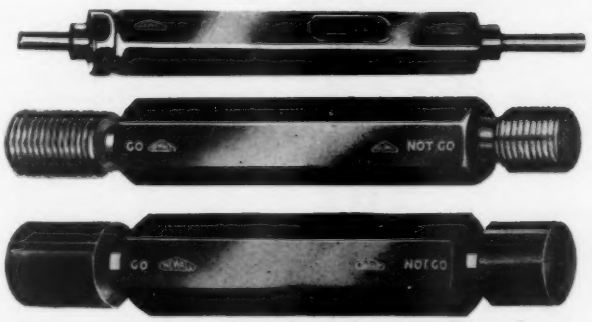

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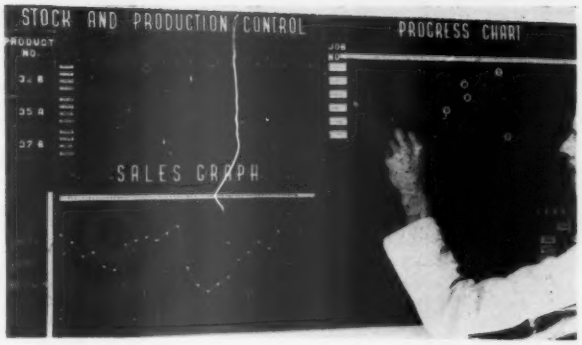

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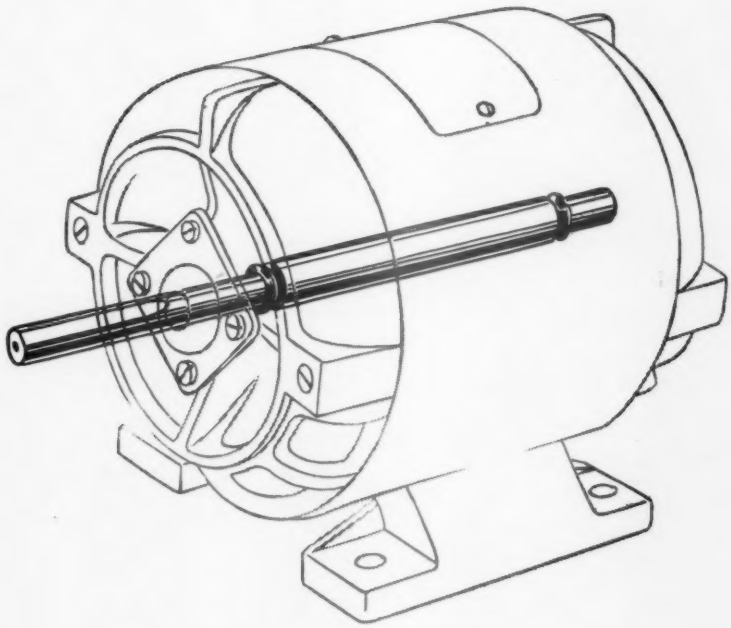

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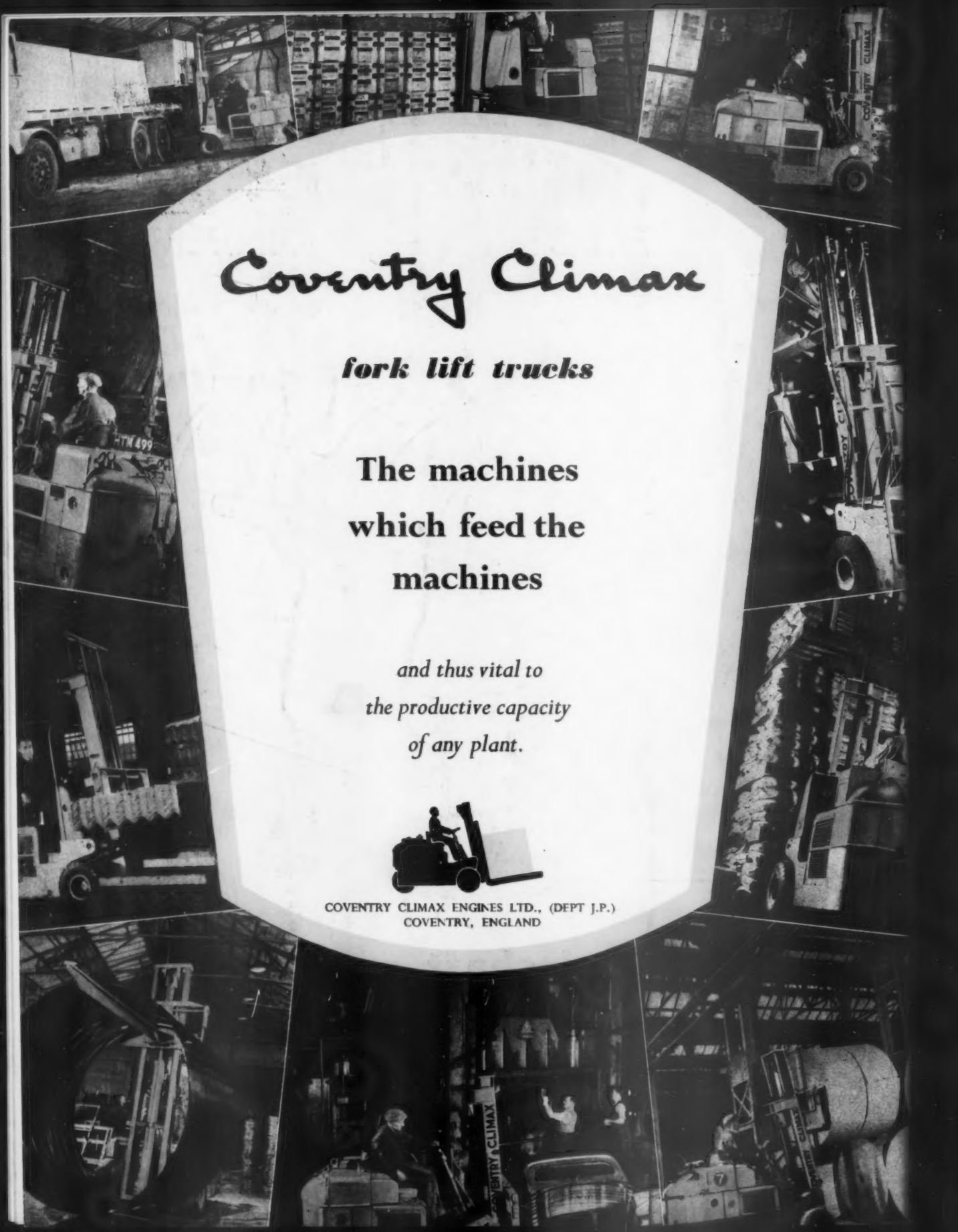

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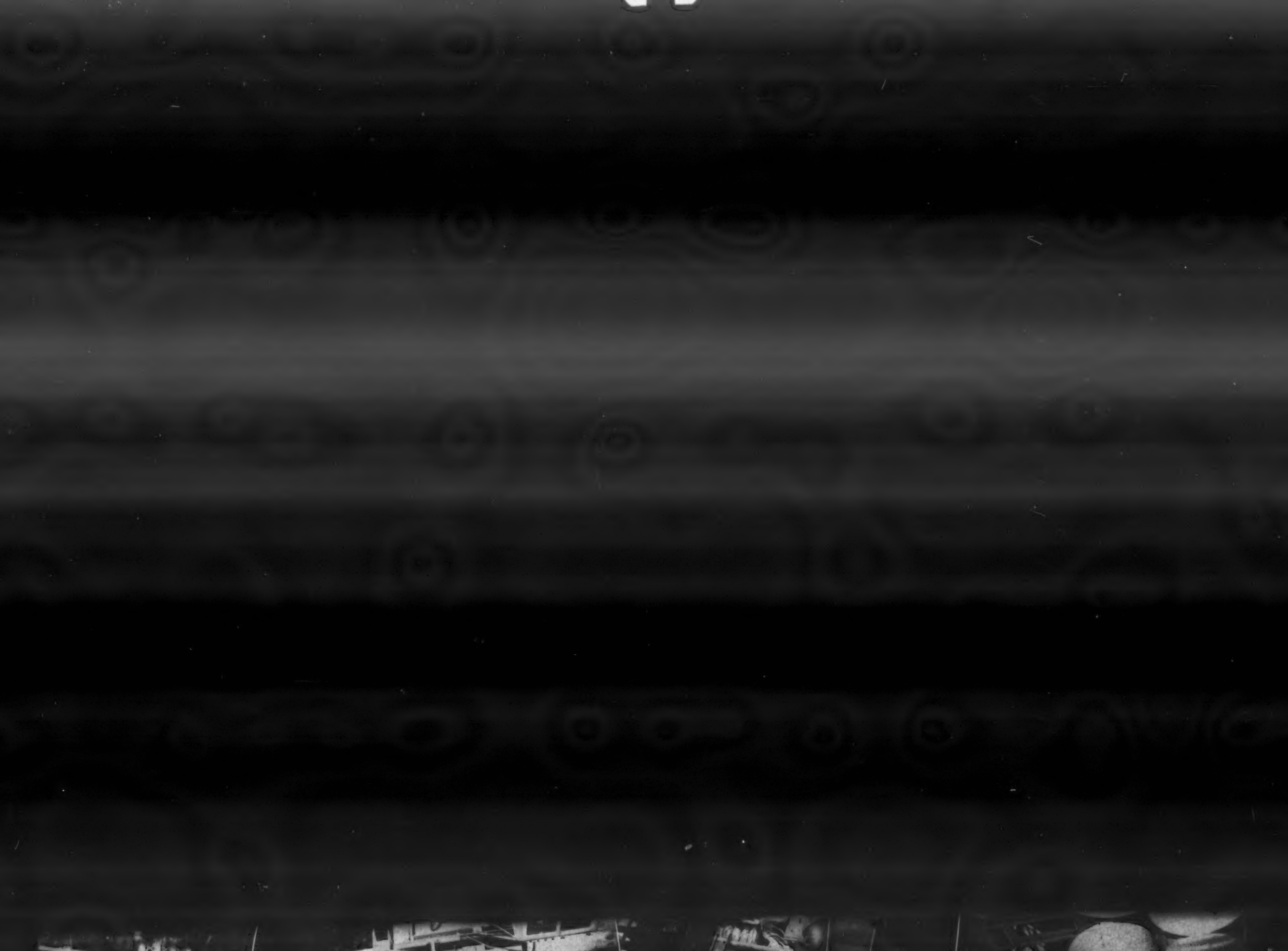

JOURNAL SUPPLEMENT

Vol. 34, No. 4
APRIL, 1955

INSTITUTION OF PRODUCTION ENGINEERS, 10, CHESTERFIELD ST., LONDON, W.1

The Automatic Factory:—

What does it mean?

NATIONAL CONFERENCE

MARGATE

16th—19th June 1955

Widespread interest both at home and abroad, has been roused by the publication of the programme for the Institution's National Conference at Margate in June, and members who wish to attend are advised to reserve their hotel accommodation without delay.★Application forms have already been distributed, but additional copies and lists of hotels may be obtained on application to the Secretary at 10, Chesterfield Street, London, W.1. An application form also appears overleaf.

Special arrangements have been made for apprentices and trainees, and it is recommended to all members that their companies might make a point of sending one or two of their best apprentices or trainees to the Conference as a form of prize and also as a valuable training exercise. Firms proposing to adopt this suggestion are asked to communicate with the Secretary.

Apprentices and trainees who are not members of the Institution may attend the Conference at half the normal Conference fee (i.e. four guineas instead of eight guineas) if they are sent by an affiliated firm or sponsored by a member of the Institution.

★ *Over 400 Conference bookings already received.*

THE INSTITUTION OF PRODUCTION ENGINEERS

CONFERENCE · MARGATE · 16th to 19th JUNE 1955

"The Automatic Factory—What Does it Mean?"

To: The Secretary,
Institution of Production Engineers,
10, Chesterfield Street,
London, W.1.

It is my intention to attend the Conference—*see note 4*

NAME..... GRADE.....

ADDRESS.....

FIRM & POSITION.....

*I shall be accompanied by my wife
*I shall be accompanied by the following guest(s) } *see note 4*

1. Name .....

   Company or firm ..... Position held.....

2. Name .....

   Company or firm ..... Position held.....

3. Name .....

   Company or firm ..... Position held.....

I enclose remittance for Conference fees as follows:-

		£. s. d.
.....	Senior members at £5. 5. 0 each (See note 2 below)	.....
.....	Graduate members at £3. 3. 0 each	.....
.....	Student members at £2 2. 0 each	.....
.....	Ladies at £1 1. 0 each	.....
.....	Non-members at £8 8. 0 each	.....
	Total £	

Signed.....

NOTES:

1. *Delete where inapplicable.
2. Senior members are Hon. Members, Members, Associate Members, Associates, Representatives of Affiliated Firms.
3. Those attending the Conference are required to make their own hotel arrangements and a list of the hotels in Margate and district will be sent to all applicants. The Secretary is willing to reserve accommodation on behalf of applicants in accordance with their instructions.
4. Please give title (Mr., Mrs., etc.), honours and degrees for each person attending. Please use block letters throughout.
5. Cheques should be made payable to: "The Institution of Production Engineers".

The 1954 George Bray Memorial Lecture

This Lecture, which is one of the three Named Papers presented anually by the Institution, will be given in **Manchester** on **Monday, 18th April, 1955.** The meeting, which has been arranged by the Manchester Section, will be held in the Reynolds Hall, The College of Technology, Sackville Street, Manchester, 1, commencing at 6.45 p.m., and the President of the Institution, Sir Walter Puckey, will be in the chair.

Admission to the meeting will be by ticket only, which may be obtained from the Secretary of the Institution at 10, Chesterfield Street, London, W.1. Non-members are cordially invited to attend. It is anticipated that preprints of the Paper will be available for distribution about a week in advance of the meeting.

Applications for tickets of admission and/or preprints of the Paper should be received **not later than Tuesday, 12th April, 1955.**

"Managing the Small Firm"

The Third "Small Firms" Conference to be organised by the British Institute of Management, with the support of the Federation of British Industries and the National Union of Manufacturers, will take place at Harrogate on 29th and 30th April, 1955.

The speaker at the opening session will be Mr. Roy Harrod, the distinguished economist, and Mr. Osbert Peake, Minister of Pensions and National Insurance, will be the principal speaker at the Closing Dinner.

Full particulars may be obtained from the Conference Secretary, British Institute of Management, P.O. Box 483, 8, Hill Street, London, W.1.

"Measurement and Control of Industrial Paint Finishing Costs"

In November last year the Paints Division of Imperial Chemical Industries Limited organised a Conference on the measurement and control of paint finishing costs, attended by representatives of many leading concerns. The Secretary of the Institution, Mr. W. F. S. Woodford, took the chair for the Second Session of the Conference.

The proceedings of the Conference have now been published, and copies may be obtained, free of charge, on application to the Paints Division, I.C.I. Ltd., Imperial Chemical House, Millbank, London, S.W.1.

Textile Institute Annual Conference, 1955

The 40th Annual Conference of the Textile Institute is to be held this year in London, at Caxton Hall, Caxton Street, London, S.W.1., from 17th/20th May. The subject of the Conference will be "Practice and Progress in the Textile Industry".

The Minister of Education, Sir David Eccles, P.C., M.P., is to address the opening session, at which the Earl of Halsbury, Managing Director of the National Research Development Corporation, will also speak on "Textiles—Technique or Technology?"

Full details of the Conference may be obtained from the General Secretary, the Textile Institute, 10, Blackfriars Street, Manchester, 3.

MEETINGS

Visitors' tickets may be obtained from Section Honorary Secretaries.

APRIL, 1955

BIRMINGHAM **7.0 p.m. APRIL 20th**
The James Watt Memorial Institute, Great Charles Street, Birmingham 3.
"The Development of Special Machines with Particular Reference to Unit Construction" by T. W. Elkington, M.I.Prod.E. (Section Chairman).

DERBY **7.0 p.m. APRIL 18th**
Irongates Hotel, Irongate, Derby.
"Birth of a Process — Production of Synthetic Alcohol" by H. E. B. Young, B.Sc., A.M.I.Mech.E.

HALIFAX GRADUATE **7.30 p.m. APRIL 6th**
Collinson's Cafe, Crown Street, Halifax.
"The Production of Modern Electric Washing Machines" by J. Senior, A.M.I.Prod.E.

LIVERPOOL GRADUATE **7.45 p.m. APRIL 5th**
The Stork Hotel, Queens Square, Liverpool.
"Planning an Archaeological Excavation" by J. H. Iliffe, O.B.E., (Director, City of Liverpool Public Museums).

LONDON **7.0 p.m. APRIL 21st**
The Royal Empire Society, Northumberland Avenue (Craven Street entrance), London, W.C.2.
"Electronics in Modern Industry" by R. H. Booth, B.Sc.

LONDON GRADUATE **7.0 p.m. APRIL 5th**
The Institution of Production Engineers, 10 Chesterfield Street, London, W.1.
Annual General Meeting and Film Evening. "Machines at Work"; "The Shortest Way" (Die Casting); "Ideas at Work" (Productivity Promotion).

LUTON **7.15 p.m. APRIL 19th**
The Small Assembly Room, Town Hall, Luton.
"Cold Forming of Light Alloys" by D. A. Barlow, B.Sc.

LUTON GRADUATE **7.45 p.m. APRIL 25th**
The Peahen Hotel, St. Albans, Herts.
"Standardised Tooling" by D. A. Wilcocks.

MANCHESTER GRADUATE **6.45 p.m. APRIL 25th**
Reynolds Hall, College of Technology, Sackville Street, Manchester.
"From Diamond to Spark Machining" by G. Fefer, A.I.Prod.E.

NORTH EASTERN **7.0 p.m. APRIL 18th**
The Neville Hall, Newcastle-upon-Tyne.
Annual General Meeting.

OXFORD **7.15 p.m. APRIL 19th**
The Town Hall, Oxford.
"A Different Way of Looking at Management" by W. B. D. Brown.

PETERBOROUGH **7.30 p.m. APRIL 16th**
The Campbell Hotel, Bridge Street, Peterborough.
Film — "Precise Measurement for Engineers" introduced by S. P. Poole.

NOTTINGHAM **7.15 p.m. APRIL 6th**
Works Visit to Myford Engineering Co. Ltd.

READING **7.30 p.m. APRIL 14th**
High Duty Alloys Ltd., Lecture Theatre, Slough.
"High Cost of Low Overheads" by C. H. Starr, M.I.I.A., A.M.I.Prod.E.

SHREWSBURY **7.30 p.m. APRIL 27th**
Shrewsbury Technical College, Shrewsbury.
"Manufacture of Springs" by John A. Roberts, M.Inst.B.E.

SOUTH ESSEX **7.30 p.m. APRIL 20th**
Mid-Essex Technical College, Chelmsford.
"Higher Management's Approach to Work Study" by J. E. Currie.

WESTERN **7.15 p.m. APRIL 6th**
Grand Hotel, Bristol.
Annual General Meeting followed by film evening.

WESTERN GRADUATE **7.0 p.m. APRIL 18th**
The Grand Hotel, Broad Street, Bristol.
Annual Lecturette Competition for the Senior Section Prize.

WEST WALES **7.30 p.m. APRIL 15th**
The Central Library, Alexandra Road, Swansea.
"Costing and Finance for Production" by E. C. Sayers, A.C.A.

WOLVERHAMPTON **7.15 p.m. APRIL 6th**
County Technical College, Stafford.
"Organisation for Production" by B. E. Stokes, A.M.I.Prod.E.

WOLVERHAMPTON GRADUATE
7.30 p.m. APRIL 20th
The Wolverhampton & Staffordshire Technical College, Wulfruna Street, Wolverhampton.
"Recent Developments in Metal Machining" by K. J. B. Wolfe, M.Sc., A.F.R.Ae.S., F.R.I.C., F.I.M., M.I.Prod.E.

PRODUCTION APPOINTMENTS

BULLETIN No. 55
APRIL 1955

The last date for receiving material for insertion in the following month's bulletin is the 20th of each month.

The fee for insertion of particulars regarding each appointment is £3 3s. (up to 100 words), and over 100 words £5 5s. A standard charge of £1 1s. per insertion is made to firms affiliated to the Institution, Technical Colleges, Universities and similar organisations.
Advertisers are advised that better response is likely if, in addition to essential qualifications, the following information is given:—

(*a*) Location of appointment; (*b*) Status in the organisation and scope of promotion; (*c*) Salary range and age range.

Advertisers are asked to advise the Institution when appointments are filled. The Institution reserves the right to refuse or withdraw any announcement and also to make any alteration in the wording to ensure conformity with the Institution standards. *Members interested in the following appointments should make application in accordance with the terms of notice. No correspondence can be undertaken by the Secretary other than the forwarding of replies to Box Nos.*

All advertisements appearing in this Bulletin are subject to the Notification of Vacancies Order of 1952.

Works Manager required for old-established medium sized engineering company. The Works comprise foundry, machine shop, plate and erection shops for the manufacture of medium-heavy engineering products. Applicants must have had first class executive and production experience in this type of work, including control of outside erection staff. Age limits are preferably 35 - 45, and the post will command an adequate four-figure salary commensurate with the qualifications of the successful applicant. Full particulars, which will be held in strict confidence, should be sent to: Box No. 1037, I.Prod.E., 10 Chesterfield Street, London, W.1.

Jig and Tool Draughtsman needed for excavator division of Newton Chambers & Company. Aged 25 - 30 with experience of designing jigs and fixtures for machining and assembling medium-sized components. The post is permanent and pensionable with excellent prospects for the selected draughtsman. Please reply giving details of age, experience and present salary to: Personnel Officer, Newton Chambers & Co. Ltd., Thorncliffe, Sheffield.

Senior Jig and Tool Draughtsman required on the tooling of heavy vehicle components. Permanent and pensionable post for the right man. Apply: Transport Equipment (Thornycroft) Limited, Basingstoke, Hants.

Press Shop Manager. Applications are invited for the position of press shop manager with a large precision engineering company in the South Eastern area. Applicants should have a first class knowledge of press tool design and manufacture and be conversant with progressive tooling practice. The successful candidate will also be required to control the press shop tool crib, machine and material planning staff, etc. Salary will be based on experience. There is a good pension scheme. All applications will be treated in strict confidence, and should state age, qualifications and experience. Box No. 1054, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Engineer, fully experienced, to take charge of ratefixing department in modern engineering works, on shift work, 30 miles north of London. Applicants must be experienced in machining and assembly of automobile products. Salary £900 - £1,000, and prospects for a keen ambitious man with the requisite experience. Housing facilities available. Box No. 1055, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Engineers. A Time Study Engineer and two Methods Engineers required. Trained men preferred but consideration given to suitable men as trainees. Salary in accordance with experience and qualifications. Posts pensionable. Five-day week. Write details to: Personnel Manager, Telcon Works, Greenwich, S.E.10.

Chief Production Engineer. A prominent manufacturer desires to appoint a Chief Production Engineer with experience of electric lamp or valve manufacture. The position calls for a person having considerable experience in lamp making machinery and manufacturing methods. Prospects are excellent. A first-rate salary will be paid to the right man and the position is fully superannuated. Own staff are aware of the vacancy. Applications in full detail to: Box No. 1056, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Production Engineer. A leading electric cable manufacturer wishes to appoint a Chief Production Engineer with good experience of cable-making plant and processes for paper, rubber and thermo-plastic products. A first-rate salary will be paid, prospects are high and post is superannuated. Detailed applications, quoting reference "Cables" to: Box No. 1057, I.Prod.E., 10 Chesterfield Street, London, W.1.

Works Manager is required by engineering company in Derby area, engaged in rebuilding and reconditioning of high precision machine tools and the manufacture of spare parts on small batch production. Knowledge of single spindle automatics is an advantage. Applicants should have good shop floor experience and ability to organise and improve, in conjunction with Technical Manager, methods of production, the meeting of production programmes and the maintenance of discipline in the works. Applicants must state full particulars of qualifications and experience, age, and salary required to: Box No. 1058, I.Prod.E., 10 Chesterfield Street, London, W.1.

Qualified Men for senior positions in the Pre-Production and Production Departments of Hawker Aircraft Limited, Kingston-on-Thames, Surrey. Applications are invited from the following:- (1) Persons already holding positions of responsibility related to the planning, manufacture and development of aircraft components or accessories. (2) Electronic/electrical engineers for work in the design office and production departments on various aspects of design, manufacture and installation. Applicants for these executive positions should possess qualifications, experience and ability to justify a substantial salary on appointment. (3) Young men with works or technical office experience with ability and initiative to achieve executive status with appropriate salary in these departments after period of general training. It is desirable that in addition to basic engineering experience all applicants should possess a University Degree or should have passed the final examination of a recognised professional body. Applications, to include full details of career and present position, to Secretary of the Company.

Time Study Engineers. Applications are invited from suitably qualified men with previous experience of machine shop, assembly flow line and metal finishing production as applicable to light engineering. Salary will be commensurate with previous experience and the responsibilities of the position. Profit sharing and indirect workers' bonuses. Canteen facilities, pension scheme, etc. Applications, quoting reference MAI/PLI/81, to: the Personnel Manager, S. Smith & Sons (England) Ltd., Cricklewood Works, N.W.2.

Planning Engineer required by large company of electrical engineers situated in South London, with experience of pre-production planning of light electro-mechanical components. Applicant should have reached H.N.C. standard and possess a sound knowledge of production methods. Applications in confidence giving full particulars to: Box 3R.QO2973, A.K. Advg., 212a Shaftesbury Avenue, London, W.C.2.

General Manager. Igranic Electric Company Limited, invite applications for the post of General Manager of their new radio component factory at Bromborough, Wirral, Cheshire. Applicants must have proved administrative and organising ability, be thoroughly conversant with the radio and electronic business, and possess drive and initiative. The post is one of considerable importance and offers excellent prospects. This firm is a member of the Metal Industries Limited Group of Companies and applications should be sent to: the Group Training and Personnel Officer, Metal Industries Limited, 60 Buckingham Palace Road, London, S.W.1, and marked M/12.111.

Estimator Salesman required to take charge of newly established sales department covering gear production and machine tools. Applicants for this vacancy must have experience of gear manufacture and be acquainted with normal sales department technique. State full particulars of experience, age and salary required. Gear Grinding Co. Ltd., Shirley, Birmingham.

Senior Design Engineer required by a large and progressive firm situated in the Midlands, for the design and development of new products in the field of L. T. switch fuse and motor control gear. Successful candidate will be required to control, under supervision, a designs drawing office together with an associated model-making workshop. Every encouragement will be given to the right man to apply original thought to his work. This post offers excellent prospects and permanency to a man having imagination, initiative and a sound knowledge of large scale production methods. Replies, which will be dealt with in strict confidence, should contain details of age, technical training, previous posts and experience and salary required to: Box No. 1059, I.Prod.E., 10 Chesterfield Street, London, W.1.

Designer required for development work with large established company manufacturing L. T. switch fuse, motor control gear and heating appliances. Previous experience in one or more of the above spheres of industry desirable. Electrical knowledge is not essential and a man with sound mechanical knowledge and large scale production experience will receive first consideration. This post offers permanency

and good prospects to candidates possessed of initiative and drive and capable of developing designs and carrying them through to their final conclusion. Applications, which will be dealt with in strictest confidence, should contain full particulars, etc. and be addressed to the Personnel Manager, Box No. 1060, I.Prod.E., 10 Chesterfield Street, London, W.1.

Senior Planning Engineers are required by the English Electric Co. Ltd., commencing at Luton, transferring soon after to Stevenage. Applicants will have ample scope for reviewing designs for suitability of manufacture, advising the drawing office regarding choice of materials and achievable tolerances, and should have experience of assembly planning and tooling for small batch quantities of work ranging from light to medium mechanical and electrical engineering. These are senior appointments and housing assistance will be available to the successful applicants from the Greater London area. Applications stating age, experience and qualifications should be addressed to: Dept. C.P.S., 336/7, Strand, W.C.2., quoting Ref. 900M.

Mechanical Engineers and Designer/Draughtsmen. Tube Investments Limited require qualified mechanical engineers and designer/draughtsmen for development work on automatic production plant in the Birmingham/Walsall area. Applicants should have experience in some of the following fields. Production engineering methods, machine tool design, pneumatic and hydraulic controls, transfer and hopper feeds, automatic furnaces and induction heating, mechanical foundry equipment, etc. Senior and junior engineers are required who have had industrial training and experience. The age ranges are approximately:—Senior Mechanical Engineer—age 28-35. Junior Mechanical Engineer—age 23-27. Designer/Draughtsman—age 25-45. Application should be made giving full particulars of age, experience, education, training and salary required to: the Personnel Manager, Tube Investments Limited, Rocky Lane, Aston, Birmingham 6.

Jig and Tool Draughtsmen and Process Planning Engineers. Light Engineering Company, N.W. London area, invite applications from experienced men as Jig and Tool Draughtsmen and Process Planning Engineers. Old established firm, good working conditions, pension scheme and canteen facilities. Interviews to applicants' convenience. Own staff notified. Interesting and varied work involving press tools, jigs, gauges, special purpose machines, and production development for precision components and assemblies in large quantities. Please write full details of experience, etc. to: Box No. 1061, I.Prod.E., 10 Chesterfield Street, London, W.1.

Trainee Work-Study Engineer required. Applicants should be of Higher National Certificate level or Graduates of a recognised Institution and have served a mechanical or electrical apprenticeship. A practical outlook is essential based on a period of shop floor experience. Age limits 23 to 30. The work is in West London but there will be opportunities for travelling to other parts of the country. Apply to: Personnel Officer, Osram G.E.C. Lamp Works, Brook Green, Hammersmith, W.6.

Development Engineer. A vacancy arises in the Glacier Metal Company Limited, Alperton, Wembley, Middlesex. The duties are concerned with development of new manufacturing methods—chiefly continuous processes—to the stage of their introduction into the works. Whilst the duties are mainly concerned with mechanical engineering, a wide range of other sciences are often involved. The successful applicant will be directly responsible to the Chief Development Engineer. To meet the requirements of this position, it is considered that applicants must have an Honours Degree in mechanical, chemical or electrical engineering, and have had some previous industrial training, preferably an apprenticeship. A knowledge of servo-mechanisms or of electronics would be advantageous. Salary will be £650/£900 per annum according to the candidate's experience and qualifications.

Production Methods Engineer required by light electrical engineering company in S.E. England, engaged in process and assembly manufacture with limited machine shop operations. The selected applicant will control a section of 6/8 Planning Engineers. Desirable qualifications should include recognised certificate in engineering, experience of electro-chemical processes, cost estimating and work study techniques and some knowledge of machine and/or tool design. The post is pensionable with a salary up to £1,000 per annum. Housing accommodation is available. Please write stating age, qualifications and experience to: Box W.Q.5726, A.K. Advg., 212a Shaftesbury Avenue, London, W.C.2.

Process Planning Engineer required for engineering works engaged in job and batch manufacture of medium-sized precision machinery for specialised industry. Applicants must have had previous experience on similar work and be capable of preparing from detailed drawings sequences for machine shop and assembly floors. Monthly staff status. Write, quoting: PE/EL, Personnel Officer, MO.Valve Co., Ltd., Brook Green, Hammersmith.

Methods Engineer required with previous experience of layouts for machine shop, assembly lines and test area on mass production of small electro-mechanical engineering equipment. Applicants should be capable of assessing prototype units and revising designs for the most economic production. Planning and tool design. They should be able to produce revised cost figures of project covering material, labour, tool and plant for presentation to works management. London area. Please reply, giving full details of experience to: Box No. 1062, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant to Technical Director required by engineering firm in Gloucestershire. Applicants, aged 30 or under, should have had a public school education, followed by either an engineering apprenticeship, university course in engineering or practical experience in the engineering industry. Excellent prospects. Salary up to £900 per annum depending on age and experience. Box No. 1063, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant to Works Manager. Applications are invited from fully experienced engineers for the post of Assistant Works Manager. The successful applicant must be capable of assuming, within four years, full control of the foundry (ferrous and non-ferrous), machine, fitting and assembly shops, together with work study and production control. The company is an old established and highly progressive engineering concern in the Manchester area, with excellent workshops and modern machine tools and services, employing 1,750 persons. The position is one of outstanding opportunity. There is a non-contributory pension fund in operation, and a starting salary of £1,500 per annum is envisaged. Write, in confidence, giving full details of age, education, training and experience, to: Box No. 1064, I.Prod.E., 10 Chesterfield Street, London, W.1.

First-class Engineer. A vacancy occurs for a first-class man to act as whole-time liaison between drawing office and engineering methods with K. & L. Steelfounders and Engineers Limited, Letchworth, who design and produce large diesel-mechanical mobile cranes. More than half his time would be spent in the drawing office, on call for advice as to machine capacity and choice of method, so as to ease and speed methods department work on receiving drawings. Applicants should be over 35, preferably from heavy vehicle or similar manufacture, and must be fresh from up-to-date batch production in a thoroughly modern works. H.N.C. is viewed favourably, but is not necessary. Past experience of tooling, methods layout and sequence is taken for granted. Tact and pleasant personality are essential. Both departments would make the right man very welcome; present staff know of the vacancy. An excellent salary is envisaged but this would be commensurate with age and calibre. Generous pension scheme in existence and assistance could be given with housing. Please write to: the Personnel Superintendent.

Senior Works Layout and Work Study Engineers. The English Electric Company at Stafford require engineers for the following posts: **Senior Works Layout Engineers** for work in light, medium and heavy electrical engineering manufacturing departments. Applicants should be well qualified in the requirements of process and plant layouts and have technical qualifications of at least O.N.C. standard and preferably be members of the Institution of Production Engineers. **Senior Work Study Engineers** for process and manufacturing development in light, medium and heavy electrical engineering. Applicants should have served a recognised apprenticeship and have a sound background of practical engineering in an appropriate manufacturing industry, together with technical qualifications to at least O.N.C. level. Applications, quoting ref: 1225E should be addressed to: Dept. C.P.S., 336/7 Strand, W.C.2.

Group Work Study Manager. A medium size group of manufacturers in Birmingham (about 1,000 employees) invites applications for the position of Group Work Study Manager, at a commencing salary at the rate of £1,500 per annum plus bonus. A time served engineer with experience of methods engineering (including estimating and tool design), work measurement and production control, who is able to maintain a high standard of quality and meet delivery promises will find ample scope and interest in this position. Applications for interview should be addressed in strict confidence to: The Chairman, Box No. 1065, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Engineering Executive. Leading aero-engine manufacturer requires qualified production engineer for senior post in large planning and methods engineering department. First-class experience of methods, tooling and planning for medium quantity production of precision components is necessary. Applicants should give full details of experience and state salary required. Box A.C.05302 Samson Clark, 57 - 61 Mortimer Street, London, W.1.

Machine Tool Designer. A brilliant Machine Tool Designer required, preferably one who has had experience with automatic machinery, both bar and chuck types. Applicant must be of proven ability, be capable of original thought and be conversant with latest developments in the world machine tool trade. Excellent salary and prospects for the right man. Please apply stating full experience, age and salary expected to: Box No. 1066, I.Prod.E., 10 Chesterfield Street, London, W.1.

Draughtsman with good workshop training and experience of machine tool design required by progressive London Company. Reply giving details of training and experience, age and qualifications to: Box No. 1067, I.Prod.E., 10 Chesterfield Street, London, W.1.

Time Study Engineer required by steel wire manufacturers to form new department. Sound knowledge of ratefixing and practical workshop experience essential. Good salary to right man. Applications giving age and details in confidence to: the Secretary, The Firth Company Limited, Warrington.

Planning Engineers. The English Electric Co. Ltd., Stevenage, have a number of vacancies at different levels for men with initiative, willing to tackle new and interesting processes and development work in the wide field of mechanical/electronic precision equipment. Qualifications looked for are:—1. Higher National Certificate or equivalent, with a full apprenticeship; 2. several years experience in methods and planning of mechanical/electronic assemblies, including the materials used; 3. ability to clear technical snags during various stages of development. These are permanent staff positions, offering excellent prospects and conditions. Housing will be available to married applicants from the Greater London area. Applications to: Dept. C.P.S., 336/7 Strand, W.C.2. (quoting ref. 900N.)

Technical Assistant required. Must have had machine shop experience and technical training up to Ordinary National Certificate standard. Apply stating age and qualifications to: Personnel Manager, Standard Telephones & Cables, Ltd., North Woolwich, London, E.16.

Production Planning Engineer required, by a London Paper Mill Engineering Company. Good prospects and conditions. Some experience with paper-making machinery an advantage. Write, stating age, experience and salary required to: Box No. 1068, I.Prod.E., 10 Chesterfield Street, London, W.1.

Planning and Methods Engineer required for interesting work on toy manufacture and Government contracts, covering development, product design, special purpose machines, tool design and tool and machine manufacture, try-outs section. Well-equipped development unit at Northampton, with main production plant located in South Wales. Applicants should have experience in press tools, assembly jigs and fixtures, welding, parkerising and finishing processes. A working knowledge of die casting and injection moulding a distinct advantage. Should be able to produce manufacturing layouts and estimates from prototype assemblies or rough schemes; specify materials, etc. Pension scheme in operation and excellent salary paid in accordance with experience. Apply in writing: The Mettoy Company Limited, 14 Harlestone Road, Northampton.

Production Controller required by old-established engineering firm in the Northampton/Bedford area expanding production. Age 35/45. Excellent prospects for first-class man with wide experience of modern methods of production planning and control. Will work initially under guidance of management consultants. Salary dependent on qualifications and experience, but not less than £1,000 per annum. Write giving details of age, education, experience, and salary required to: Box No. 1069, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant to Production Controller required by old-established engineering firm in the Northampton/Bedford area expanding production. Age 30/40. Excellent prospects for man with experience of modern methods of production control and especially materials control. Will work initially under guidance of management consultants. Salary dependent on qualifications and experience, but not less than £800 per annum. Write giving full details of age, education, experience, and salary required to: Box No. 1070, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Engineers. Attractive careers open to production engineers with leading management consultants. University degree in engineering, or equivalent. Sound experience in works layout, design, methods of manufacture and work study, with preference to those with successful management background. Age 33-45. Substantial earnings based on salary and other emoluments; contributory life assurance and pension scheme; attractive prospects for successful men. Write age, education, qualifications, experience and earnings to: Box No. 1071, I.Prod.E., 10 Chesterfield Street, London, W.1.

Layout Draughtsmen—Production and Layout Engineers—Methods Engineers wishing to join the motor industry are invited to send details of their experience to: the Secretary, British Light Steel Pressings Limited, Warple Way, Acton, W.3, or telephone SHE 1230.

Senior Production Engineer. A firm of electric motor control gear manufacturers require a senior Production Engineer capable of acting as Deputy to Chief Production Engineer. He should be between 30 and 40 years of age, and an A.M.I.Prod.E. and preferably Grad.I.Mech.E. Apprenticeship or post-graduate training in light engineering (batch production) and subsequent practical and supervisory experience in estimating, pre-planning, methods and time study in machining and assembly of components is required. Preference will be given to an engineer with recent training in modern techniques. Send personal and academic particulars together with experience to: Personnel Manager, Brookhirst Switchgear Limited, Northgate Works, Chester.

Engineer under 50 required by national organisation for duties which include visiting engineering firms throughout the country, meeting executives, and giving talks and demonstrations to production personnel. Applicants must have had considerable experience of manufacturing methods in industry. Good commencing salary for successful applicant, with increments on merit. Car provided and other travelling expenses paid. Excellent superannuation scheme. Applications giving full details of experience, qualifications, age and salary required to: Box No. 1072, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Engineers required by Glacier Metal Co. Ltd., for methods development work over a wide field. Positions offer good prospects to men of H.N.C. standard with experience on methods development work and sound workshop experience, who have ability to develop new ideas. Minimum starting salary at least £700 per annum. Apply: Personnel Manager, Ealing Road, Alperton, Middlesex.

Assistant Works Manager for General Engineers in N. London. Mature man who has held similar position, and with all-round knowledge of machine shop, copper smithing and welded fabrication. Work consists of specialised one-off jobs up to small batches and is not suitable for mass production. Good salary and prospects. Pension scheme. Full details including salary to: Box No. 1073, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Production Controller required by a large engineering organisation in the Wolverhampton area (6,000 employees). Applications are invited from men who have had previous experience in senior positions in large undertakings and are able to initiate the latest methods in this branch of production engineering. He will be responsible for directing the functions of the various production control departments of other companies within the group and therefore should be a man of good personality and able to work with staff at all levels. Commencing salary will depend on qualifications, but will not be less than £1,250 per annum. Applications giving full details of education, early training and appointments held, in chronological order, should be addressed to: the General Production Manager, Box No. 1074, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Production Engineer. Applications are invited for this senior appointment by a large engineering company in the Wolverhampton area. The successful applicant will be directly responsible to the General Production Manager for the production engineering functions in a works employing 6,000 people. He must have all-round experience in production engineering techniques and be able to work well with personnel at all levels. The products of the group cover a wide range of engineering structures, heavy pressings and component parts for the automobile industry. This is an important appointment and a first-class man is required. Commencing salary will depend upon experience and qualifications, but will not be less than £1,500. Applications should give details of education, technical and practical training in chronological order. All letters should be addressed to: the General Production Manager, Box No. 1075, I.Prod.E., 10 Chesterfield Street, London, W.1.

General Manager. A progressive and expanding South Yorkshire small tools factory will shortly require a General Manager. Applications are invited from executives with proven successful records, preferably in the small tools industry, and who are qualified production or mechanical engineers. The successful candidate will be responsible to the Chairman for all Company functions—technical, production, commercial, accounting. Preference will be given, therefore, to those with direct experience of commercial activity in addition to a sound technical and production background. The salary will be commensurate with responsibilities and qualifications and the successful candidate will be covered by the Company's pension scheme. Letters (confidential) of application, detailing age, education, qualifications, experience and salary required, should be addressed to: Box 191, R. Anderson & Co., 14 William IV Street, London, W.C.2.

Methods Engineer required for interesting progressive post in capacitor firm in S.W. London. Previous capacitor experience not necessary, but training to O.N.C. standard essential. Please write giving details of experience, age and salary required to: Box No. 1076, I.Prod.E., 10 Chesterfield Street, London, W.1.

Engineer required for the Motor Accessory Division of S. Smith & Sons (England) Ltd., Cricklewood Works, N.W.2. Applicants should have practical experience, a sound knowledge of gearing and a minimum qualification of A.M.I.Mech.E., or equivalent. The work involves the development of new products from established principles and supervision of the work of draughtsmen. Not least desirable is the ability to work as an important member of a team. An excellent salary will be paid to the right man, who will also be eligible for membership of the pension fund and participation in profit-sharing and indirect workers' bonuses. Fullest details, please, to: the Personnel Manager, ref: MAI/PLI/88.

Production Engineer required for light clothing factory in Essex. Must be experienced in the application of time study to this field. Experience in dress manufacture preferable but not essential. Good salary and excellent prospects for keen and energetic and capable man. Please reply giving full details of training and experience to: S. & L. Deyong, 28/31 Houndsditch, London, E.C.3.

Works Manager required for a light/medium engineering factory in the Home Counties employing 1,500. The successful candidate will be a trained engineer, with previous executive responsibility and knowledge of negotiating procedure as applying to an industrial establishment, and he will also be able to lead a mixed team of production and administrative personnel with energy and enthusiasm. The post is a senior one and offers considerable future prospects in a virile and expanding organisation. Please send full particulars of age, qualifications and experience, with salaries earned, to: Box No. 1077, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant Chief Planning Engineer. B.O.A.C. invite applications for a senior appointment in their headquarters building at London Airport as Assistant Chief Planning Engineer. The duties cover the planning of the maintenance and overhaul of aircraft, engines and accessories, including the application of improved techniques resulting from methods studies. Candidates, up to 40 years of age, should possess a university degree, Higher National Certificate or membership of one of the professional engineering Institutions and have had experience in a position of responsibility in work of a similar character to that outlined above. The salary will be in accordance with experience and qualifications. There is a contributory pension scheme. Applications stating age, past and present posts held, qualifications and experience, should be sent to: Chief Personnel Officer, Airways House, Brentford, Middlesex.

Estimating Engineer required in expanding organisation. Applicants should be between 35/40 years of age, have a H.N.C. in mechanical or production engineering, and preferably have experience of the telephone or electronic industry. Apply: Personnel Officer, Airmec Limited, High Wycombe, Bucks.

Senior Planning Engineer required by electronic engineering company. Minimum standard O.N.C. electrical or mechanical with at least five years experience as Planning Engineer in the radio or telephone industry. Apply: Personnel Officer, Airmec Limited, High Wycombe, Bucks.

Technical Sales Representative, resident in N. England, required by well-known company specialising in technical production and workshop equipment. Requirements include good technical and practical training, and personality. Sales

experience useful but not essential, providing applicant is keen to make technical sales his career. Good salary and prospects. Box No. 1078, I.Prod.E., 10 Chesterfield Street, London, W.1.

Young Technical Sales Assistant required for London office of well-known company specialising in technical production and workshop equipment. Good technical background essential, office experience an advantage. Salary according to aptitude, good prospects for advancement. Box No. 1079, I.Prod.E., 10 Chesterfield Street, London, W.1.

EDUCATIONAL APPOINTMENTS

Twickenham Technical College, Egerton Road, Twickenham, Middlesex.

Assistant (Grade B). Required May 1st, 1955, or as soon as possible:—Assistant (Grade B) to teach production engineering subjects up to Higher National Certificate and Final City and Guilds levels. Candidates should have had good industrial and preferably some teaching experience: a degree or equivalent qualification is desirable. Salary in accordance with the Burnham Technical Report 1954 (London Area). Application form and further particulars (stamped addressed foolscap envelope) from the Principal to whom completed forms should be returned within fourteen days of the appearance of this advertisement.

Dudley & Staffordshire Technical College, Dudley.

Lecturer in Production Engineering. Applications are invited for the appointment of Lecturer in Production Engineering, to take effect from 1st September next. Applicants should have good technological qualifications, industrial and teaching experience, and should be corporate members of either the I.Mech.E. or the I.Prod.E. The successful candidate will be required to offer the subjects of machine tools and metrology to H.N.C. standard. Salary scale for the above post—Burnham Technical—£965 by £25 to £1,065. Application forms and further particulars may be obtained from the Principal, Dudley & Staffordshire Technical College, Dudley, to whom the completed forms must be returned by not later than Thursday, 14th April, 1955.

Kingston Technical College, Fassett Road, Kingston-on-Thames.

Senior Lecturer in Production Engineering. Required in September, Senior Lecturer in Production Engineering. Candidates should be graduates or possess equivalent professional qualifications. They should have specialised in production engineering, and be corporate members of the Institution of Production Engineers. Teaching experience essential, and experience in teaching management subjects would be an additional qualification. Salary (Men): £1,065 x £25—£1,215 per annum plus London Allowance. Further particulars and form of application obtainable from the Principal on receipt of stamped addressed envelope. Applications should be returned not later than 30th April.

Loughborough College of Technology, Loughborough.

Assistant Shop Superintendent. Applications are invited for the post of Assistant Shop Superintendent of the tool room and grinding department. The person appointed will be required to give practical instruction to full-time engineering students in engineering workshop production processes, and in production. Applicants should have had good industrial experience, including experience in tool room and gauge work, precision grinding and tool grinding, and precision measurement. Experience of teaching is desirable, but not essential. Salary will be paid according to the scale for Assistant Lecturers, Grade A, of the Burnham Committee Report, 1954, namely:—£450 x £18—£725. Application forms and further particulars may be obtained from the Registrar, to whom completed applications should be returned as soon as possible.

National College of Rubber Technology, Northern Polytechnic, Holloway, N.7.

Lecturer in Mechanical Engineering. The Board of Governors invite immediate applications for appointment as Lecturer in Mechanical Engineering, with special reference to the rubber and plastic industries. Candidates should possess an engineering qualification with experience of rubber or a diploma in rubber technology with engineering experience. Salary scale—£1,015 x £25 x £1,115. Form of application, together with full particulars, will be sent on receipt of a stamped, addressed foolscap envelope from the Clerk, National College of Rubber Technology, Northern Polytechnic, Holloway, N.7.

County Technical College, Gainsborough, Lincs.

Assistant Lecturer. Applications are invited for the post of Assistant Lecturer to teach machine shop and production engineering subjects. Candidates should have had adequate teaching and industrial experience and be able to teach at least two of the following to Higher National Certificate level: jig and tool design, metrology, machine tools. Salary in accordance with the Burnham Scale for teachers in establishments of further education (Grade B). Further particulars of the post and application forms may be obtained from the County Technical College on receipt of a stamped addressed foolscap envelope. Completed applications should be returned as soon as possible, to: the Principal F. J. Birkbeck, Director of Education, P.O. Box 20, County Offices, Lincoln.

Brooklands County Technical College, Heath Road, Weybridge.

Assistant Grade B in Production Engineering. Applications are invited for the post of Assistant Grade B in Production Engineering. The work will be concerned with Ordinary National Certificate courses in production engineering and City and Guilds courses in allied subjects. Applicants should possess sound technological qualifications, good industrial and teaching experience. Preference will be given to those with a knowledge of machine tools, jigs and fixtures, metrology, heat treatment and welding practice. Salary scale: (Men): Grade B £525 x £25—£820 per annum. Application forms and further particulars obtainable on receipt of stamped addressed envelope from the Principal, to whom they should be returned within 14 days of the appearance of this advertisement.

North-West Kent College of Technology, Dartford, Kent. Engineering Department.

Lecturer in Production Engineering. Applications are invited for the post of Lecturer in Production Engineering on the staff of the mechanical engineering department. Candidates should have a good degree or equivalent qualification and have had industrial and some teaching experience. Special experience in either jig and tool design, metrology or metallurgy an advantage. The person appointed will be required to teach production engineering up to the standard of C. & G. final examination in machine shop engineering and of Higher National Certificate in production engineering. He will also be required to assist in the development of the production engineering courses, and post-Higher National Certificate courses in productivity. Salary: £965—£1,065.

The College of Aeronautics, Cranfield, Bletchley, Bucks. Chair of Aircraft Economics and Production. The Governing Body invites applications for appointment as Professor and Head of the Department of Aircraft Economics and Production at The College of Aeronautics, which post will become vacant at the end of the current academic year. It is hoped to make the appointment from 1st August, 1955. The salary will be in accord with the current range for professorial salaries obtaining in Universities, with superannuation under the Federated Superannuation system for Universities and family allowance. The salary on appointment will be dependent upon the qualifications and experience of the successful candidate. A house at a reasonable rent will be available if required. Further details can be obtained from: The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks. Applications for the post should be received not later than 30th April, 1955.